551.573
458
WJ wa

DEC 12 1922

W. B. No. 786

U. S. DEPARTMENT OF AGRICULTURE

WEATHER BUREAU

MONTHLY WEATHER REVIEW

VOLUME 50, No. 9

SEPTEMBER, 1922

WASHINGTON
GOVERNMENT PRINTING OFFICE
1922

CERTIFICATE: By direction of the Secretary of Agriculture the matter contained herein is published as administrative and statistical information and is required for the proper transaction of the public business.

The Weather Bureau desires that the MONTHLY WEATHER REVIEW shall be a medium of publication for contributions within its field, but the publication of contributions is not to be construed as official approval of the views expressed.

ECONOMIES IN PRINTING.

Contributions intended for publication in the REVIEW must in all cases conform to the regulations of the Department of Agriculture with respect to effecting economies in the public printing. The following memorandum in regard to preparing manuscripts for publication is reproduced for the information of all concerned.

Authors will be expected to prepare their manuscripts, with the understanding that once the manuscript leaves the author's hands it is in final form and not subject to further changes of text in galley or page proof. With the adoption of this policy it will be necessary that authors consult workers on related subjects in other Bureaus before finally submitting their manuscript for publication, and all matters as to which there is difference of opinion must be settled in advance.

BACK NUMBERS OF THE REVIEW WANTED.

The Weather Bureau has not enough of the following numbers of the MONTHLY WEATHER REVIEW to meet even urgent requests for filling up files at institutions where the REVIEW is constantly being referred to. The return of any of these or of any 1919 or 1920 issues, especially November, 1919, will be greatly appreciated. An addressed franked slip may be had on application to the Chief, U. S. Weather Bureau, Washington, D. C.

1914: January, February, March, April, September, October, December.
1915: May, June, July, August.
1916: January, August.
1917: June.
1918: February, September.
1919: Any issue, especially November.
1920: Any issue, especially January.
SUPPLEMENT, No. 3.

MONTHLY WEATHER REVIEW

ALFRED J. HENRY, Editor.

VOL. 50, No. 9.
W. B. No. 786.

SEPTEMBER, 1922.

CLOSED NOVEMBER 3, 1922
ISSUED DECEMBER 4, 1922

THE PREPARATION AND SIGNIFICANCE OF FREE-AIR PRESSURE MAPS FOR THE CENTRAL AND EASTERN UNITED STATES.[1]

By C. LEROY MEISINGER, Meteorologist.

[Author's abstract.]

[Weather Bureau, Washington, D. C., Oct. 15, 1922.]

NOTE: There has been issued recently under the above title MONTHLY WEATHER REVIEW SUPPLEMENT No. 21. It has been the practice to present in the MONTHLY WEATHER REVIEW rather full abstracts of the material contained in the SUPPLEMENTS. This step is made in the interest of printing economy, for it is the hope that the general reader may be satisfied in this way without necessitating a large edition and without entailing waste through indiscriminate distribution of the SUPPLEMENTS. Therefore, those who find this subject one of special interest, and who desire to procure the complete discussion, may do so by applying to the Superintendent of Documents, Government Printing Office, Washington, D. C., who carries a limited supply in stock. The publication contains 77 pages, 31 figures, and 22 lithograph charts. The price is 25 cents.—EDITOR.

It is the purpose of this abstract to present concisely that material which has not been used in previous publications dealing with this subject. The material is largely excerpted from the extended publication mentioned above. Many tables, numerous figures and charts have not been reproduced. It is hoped, nevertheless, to illumine the salient features of the discussion, allowing the reader who so desires to seek the details in SUPPLEMENT 21.

Those who have followed previous papers concerned with this research,[2] are aware of the principal difficulty confronted in the attempt to reduce barometric pressure from the elevation of the barometer to some arbitrary level. It is the difficulty of knowing accurately the mean temperature of the intervening column of air. If the reduction is to be upward, the air column is real; if it is to be downward, as at present in reducing to sea level, there is no actual air column, and, in this latter case, the problem is to find a temperature value which will yield smooth isobars. This paper is concerned with reduction upward, hence, with the determination of actual air temperatures.

There is scarcely a meteorological element that is more irregularly variable with change of altitude than temperature. The value of θ that would be ideal may be defined as a mean determined by integrating the current vertical temperature curve throughout the length of the air column under consideration. But this is manifestly impracticable. The equipment necessary for the observation of free-air temperatures can not be provided for the individual stations; and, if it could, the time required for the reduction of observations would render the plan ineffectual for the forecasting of weather. *The presen problem, therefore, becomes that of finding some clue, or index, observable at the surface, that will lead to a close approximation of the mean temperature of the air column.* When one considers the almost infinite variety of surface and free-air conditions that bear directly upon the temperature of the air column, the search seems, at the outset, rather unpromising; but the way is opened through the use of the surface-wind direction as a basis of classification.

The attempt to draw free-air pressure charts is not new. It has been attempted in one form or another and for various purposes by Teisserenc de Bort,[3] Köppen,[4] Bigelow,[5] Sandström,[6] Dietsch,[7] and Fujiwhara.[8] As long ago as 1882, Professor Abbe[9] said: "In fact, for all cases, the only natural method of reduction would seem to consist in an attempt to reduce upward through the actually existing atmosphere (whose temperature and moisture can be observed) to a uniform altitude."

WIND DIRECTION AS AN INDEX TO TEMPERATURES IN THE FREE AIR.

The need for an index.—In reducing to upper levels three elements are accurately known—(1) the vertical distance between the station and the reduction level, (2) the surface pressure, and (3) the surface temperature. There are two elements to be determined, (1) the mean temperature of the air column, and (2) the mean vapor pressure of the air column. The mean temperature affords the greater problem, for the water vapor effect is less influential. If the mean temperature can not be observed, it is imperative that some index, *observable at the surface*, be employed. What shall this index be?

The qualifications of an index.—There are two qualifications to which such an index must conform: (1) It must have a direct physical relation to the temperature in the free air, and (2) it must be one of the weather

[1] A thesis presented to the Faculty of Graduate Studies, George Washington University, in part satisfaction of the requirements for the degree of Doctor of Philosophy, May 29, 1922.

[2] Meisinger, C. LeRoy: Preliminary steps in the making of free-air pressure and wind charts. MO. WEATHER REV., May, 1920, 48: 251-263; Progress in making free-air pressure and wind charts. *loc. cit.*, April, 1921, 49: 238-239; The Toronto symposium on pressure reductions. *loc. cit.* December, 1921, 49: 655-657.

[3] Étude sur la circulation génèral de l'atmosphère. *Annales du Bureau Central Météorologique de France*, 1885, Part IV, Météorologie général, second partie, pp. 35-44.

[4] Über die Gestalt der Isobaren in ihrer Abhängigkeit von Seehöhe und Temperatur-Verteilung. *Meteorologische Zeitschrift*, December, 1888, pp. 470-481.

[5] Report on the barometry of the United States, Canada, and the West Indies. *Report of the Chief of the Weather Bureau, 1900-1901*, Vol. II.

[6] On the construction of isobaric charts for high levels in the earth's atmosphere and their dynamic significance. *Transactions of the American Philosophical Society*, N. S., Vol. XXI, Part I, pp. 31-96.

[7] Untersuchungen über die Änderungen des Windes mit der Höhe in Zyklonen. *Veröffentlichungen des Geophysikalischen Instituts der Universität Leipzig*, Band II, Heft 5, 1918, pp. 197-234. Abstract in MO. WEATHER REV., July, 1920, p. 402.

[8] Pressure maps at 3 kilometers in Japan. MO. WEATHER REV., October, 1921, pp. 571-572.

[9] Appendix 61, *Report of the Chief Signal Officer*, 1882, Part 1, p. 826.

elements regularly observed at stations. The first of these qualifications is *scientifically* pertinent; the second is *practical*. It is often inadvisable to infuse too much of the purely practical into the preliminary research relative to such a problem as this; but in this case it seems evident that the factors of simplicity and practicability are inseparable from the scientific solution of the problem. For that reason it is desirable to impose this qualification upon the element selected.

Comparison of wind direction and atmospheric pressure as temperature controls in the lowest levels.—A careful consideration of the various elements observed regularly at meteorological stations will invariably eliminate all but one (excluding temperature and pressure, which are essential to the formula as stated above), and that one is *wind direction*. Surface pressure and temperature do, however, call for a word in this connection. Leaving the question of the cause of irregular barometric fluctuations, i. e., the cyclones and anticyclones of extratropical latitudes out of consideration, it is sufficient to say that temperature changes in the lowest levels of the atmosphere (only the lowest 2 kilometers will be considered here) are the result of the importation of warmer or cooler air. Such importation is the result of the blowing of the wind, and the blowing of the wind is the result of a pressure gradient, however established.

Many important discussions have centered about the cause of temperature changes in the free air, some meteorologists adhering to the belief that such changes are essentially dynamic in character,[10] and others that the changes result through the importation of air of different temperature.[11] But these discussions concern themselves with conditions at higher levels than are of interest here. It is generally agreed, it seems, that in the United States the temperature, owing to the continental character of the weather controls, at least below 3 kilometers, is more strongly related to the cource of the air (hence to wind direction) than to such effects as dynamic and radiational heating and cooling.

In 1919, correlation coefficients were worked up by W. S. Cloud, at that time assistant in the Aerological Division of the Weather Bureau, showing the relation between temperature, pressure, and the south component of the wind at the surface and at 3 kilometers, based upon approximately 200 observations. These gave values opposite in sign to those determined in Europe, and led Mr. Gregg to conclude that the factor of continentality with the attendant marked effects of wind direction was the cause of the obliteration of such dynamic effects as were pointed out by W. H. Dines, in England. Mr. Gregg states, in conclusion: "These figures [Cloud's correlation coefficients] confirm the conclusions already given, viz, that in the United States, particularly in the interior portions, wind direction exerts a greater influence on the air temperature than does the sea-level pressure." One may attribute wind direction to pressure distribution, but, in such event, the relation is, at best, only indirect between pressure and temperature, whereas between wind direction and temperature it is direct. This disposes of the measured element of surface barometric pressure as an index to upper temperatures.

Wind direction and temperature at the surface in relation to free-air temperatures.—Similarly, there is a good correlation in the United States, between surface temperature and wind direction. This holds at least as high as 3 kilometers. While, in considering seasonal or monthly normals, there appears to be a certain relation between temperature at the surface and at some free-air level, it is obvious that such a relation can not be expected to hold uniformly under day-to-day conditions. The vertical distribution of temperature is not constant, nor even regularly variable, but one which varies with type of weather, time of day, topography, etc. It is apparent, then, that if the relation between surface temperature and free-air temperature were used, it would have to be classified according to some other condition more representative of the type of weather. Wind direction would offer such a classification for reasons given above. Thus, it seems that wind direction stands as the logical element by which temperatures in the free air in the United States may be judged most readily; both surface pressure and temperature are but indirectly related to free-air temperature, while wind direction at the surface—the consequence of both these elements—is directly related.

General pressure distribution as an index.—It has been suggested that the position of the station with reference to the distribution of pressure should be the criterion for the estimation of temperatures aloft. It is believed, however, that this criterion fails with respect to the qualification of practicality. An observer *must* be able, without knowledge of widespread conditions, to apply whatever criterion is adopted Obviously, it is not until all the observations are collected upon the synoptic chart that one can determine the station's location with respect to the quadrant of the cyclone or anticyclone. Hence, this suggestion is, for current reductions, entirely impractical. If it were possible, as it is in statistical summaries, there is the additional drawback of being unable to assign the station definitely to a proper barometric situation.[12] Wind direction, however, being a direct result of the barometric situation, affords a satisfactory and simple expedient, and such classification is, in the last analysis, classification by pressure distribution.

The time element in wind direction.—One point has been raised in discussion that is worthy of careful consideration. Suppose that at a certain observation the temperature is $-15°$ C. and the wind south, of moderate velocity, but that it has changed to south only within the last hour. The observer using his observations as the fundamental data computes the probable mean temperature of the air column upon the basis of a south wind at the surface. Suppose, moreover, that the wind blows steadily from the south for 24 hours and in that time the surface temperature has risen to 0° C. under its influence. The mean temperature of the air column will be quite different in the two cases, as is the surface temperature; but, since the south wind was blowing at both observations, the observer will consider that the difference between the mean temperature of the air column and the surface temperature is the same at these times. Is such a device justified? This is a question of genuine importance for an answer to which one must look to the testimony of observations. The only answer that the writer can give at this time is based upon some statistical data gathered from the aerological stations at Mount Weather, Va., Drexel, Nebr., and Elllendale, N. Dak., and published in connection with preliminary considerations of this question of reduction upward.[13]

[10] Dines, W. H:: The characteristics of the free atmosphere. *Geophysical Memoires, No. 13*, Brit. Meteorological Off., 1919. Abstract MO. WEATHER REV., September, 1919, pp. 644-647, by W. R. Gregg.

[11] Gregg, W. R.: Vertical temperature distribution in the lowest 5 kilometers of cyclones and anticyclones. MO. WEATHER REV., September, 1919, pp. 647-649.
Douglas, C. K. M.: Temperature variations in the lowest 4 kilometers. *Quarterly Journal of the Royal Meteorological Society*, January, 1921, pp. 23-46.

[12] Except in the case of special investigations, such as the study of the dynamics of cyclones and anticyclones, this classification has been abandoned by the United States Weather Bureau in favor of classification by surface wind direction.

[13] Meisinger, C. LeRoy: Preliminary steps in the making of free-air pressure and wind charts. MO. WEATHER REV., May, 1920, pp. 255-267.

If there is a marked difference between the air column temperature when the wind has just set in and after it has been blowing for a considerable time, the probable variation or standard deviation of the individual cases from the mean should be large. In other words, if the probable variation is small, the individual observations must agree closely with the mean, and the time interval between onset and observation must be of slight importance. It was found that, taking the observations as a whole, at the three stations mentioned, the probable variation of the mean temperature of the air column from the mean in reducing to 1 kilometer above sea level (roughly, an air column of 700 meters) is only 1.3° C.; to 2 kilometers it is only 1.8° C., being slightly greater at inland than at coastal stations. In terms of pressure at ordinary conditions these variations are of the order of 0.5 mb. and 1.2 mb. at the two levels, respectively. It is believed that errors of this order of magnitude would not be serious, especially if they are distributed over considerable areas rather than localized. This is not to say that the consideration of the time factor would not reduce the probable variation, but it seems that the labor and tedium of this further classification would hardly be justified by the degree of increased accuracy.

The turning of wind with altitude.—The argument may be advanced that a certain wind direction at the surface does not necessarily indicate the turning of the upper wind and that, using the argument that importation is the chief factor in determining temperatures below 3 kilometers, an upper temperature may be quite different at two observations when the surface temperature and wind direction are the same; but the same argument advanced above will hold here. If such cases do occur (and they undoubtedly do), they are not frequent enough to exercise appreciable effects upon the reduced pressure.

But there is another way to approach the problem, and that is to study the results of aerological observations which have lately been summarized for the eastern and central United States by the Weather Bureau Aerological Division.[14]

We know that, as greater and greater elevations are attained by kites, pilot balloons, and other means, there is frequently and usually a turning of the wind, sometimes to the right and sometimes to the left. It is not of much importance whether this turning is much or little, *so long as it is the same under similar surface conditions.*

It follows, therefore, that if the turning is not the same under all conditions the deviation from surface direction should be small, if surface direction is to be a reliable index. In other words, surface wind direction may be regarded as a satisfactory guide to upper temperatures (1) if turning with altitude is constant, or nearly so, or (2) if deviation from surface direction is small. Mr. Gregg has arranged tables extremely convenient for this test.[15] In Table 10c is given the average deviation in degrees of the free-air winds from surface direction at different elevations above the several kite stations. In Table 15c is given the average percentage frequency of clockwise and counterclockwise turning for the same elevation and the same stations. The curves in the accompanying figure 1 are carried to the 3-kilometer level in order that the proper trend at the 2-kilometer level may be shown.

[14] Aerological Survey of the United States. MO. WEATHER REV. SUPPLEMENT NO. 20.
[15] *Ibid.*, pp. 56 and 68.

It will be seen that the average elevation of the six stations is 250 meters and that the elevations are given above sea level. For each wind direction at the surface (8 points) there are three curves—summer, winter, and annual deviation. The small numbers just below the surface level indicate the wind direction in degrees, measuring clockwise from north, while the wind directions indicated near the 3-kilometer level are for 16 compass points. Above each of the eight points of the surface wind are shown frequency polygons of the average clockwise and counterclockwise turning expressed as percentages of the total observations. The darker shading indicates clockwise and the lighter shading counterclockwise turning, while the unshaded portion indicates no turning at all. The deviation curves for the southeast wind, owing to their marked and rapid turning toward the west, are to be found in the lower tier at the left.

It will now be instructive to examine these curves with special reference to the consideration set forth above. In the first place, what of the constancy of turning? For this we may study the eight polygons. Taking a broad survey of the eight graphs, we find that there is a marked seasonal difference, as well as a difference between the several directions. The outstanding features of the polygons may be enumerated as follows:

(1) There is more frequent turning of winds from surface direction in all seasons at the 2-kilometer level than at the 1-kilometer level. This is a well-known fact, but a short table of the percentage of times there is *no* change is of interest, the annual average only being considered.

TABLE 1.—*Percentage frequency of no turning of wind with altitude (annual average).*

Elevation.	N.	NE.	E.	SE.	S.	SW.	W.	NW.
1 km	53	44	33	22	35	38	44	53
2 km	27	33	16	12	14	23	31	44

It is clear from this table that northerly winds are the deepest and most likely to persist up to the 2-kilometer level, while east, southeast, and south winds are most likely to turn below this level.

(2) At the 1-kilometer level clockwise turning occurs most frequently with southeast winds and least frequently with northwest winds, the transition from one to another being quite gradual.

(3) At the 1-kilometer level counterclockwise turning occurs most frequently with northwest and north winds, and least frequently with southeast and south winds, the frequency of clockwise turning being rather small.

(4) At the 2-kilometer level clockwise turning occurs most frequently with southeast winds and least frequently with northwest or north winds.

(5) At the 2-kilometer level counterclockwise turning occurs most frequently with north and northeast winds and least frequently with southeast winds, the frequency relative to clockwise turning being considerably greater, especially with northerly winds, than is the case at the 1-kilometer level.

(6) The first precept—that concerning the greatest constancy of turning—is fulfilled by southerly winds, especially southeast.

Let us now examine the portion of the diagram dealing with the average deviations from surface direction, bearing especially in mind the importance of the *amount* of the deviation and its relation to the constancy of turning

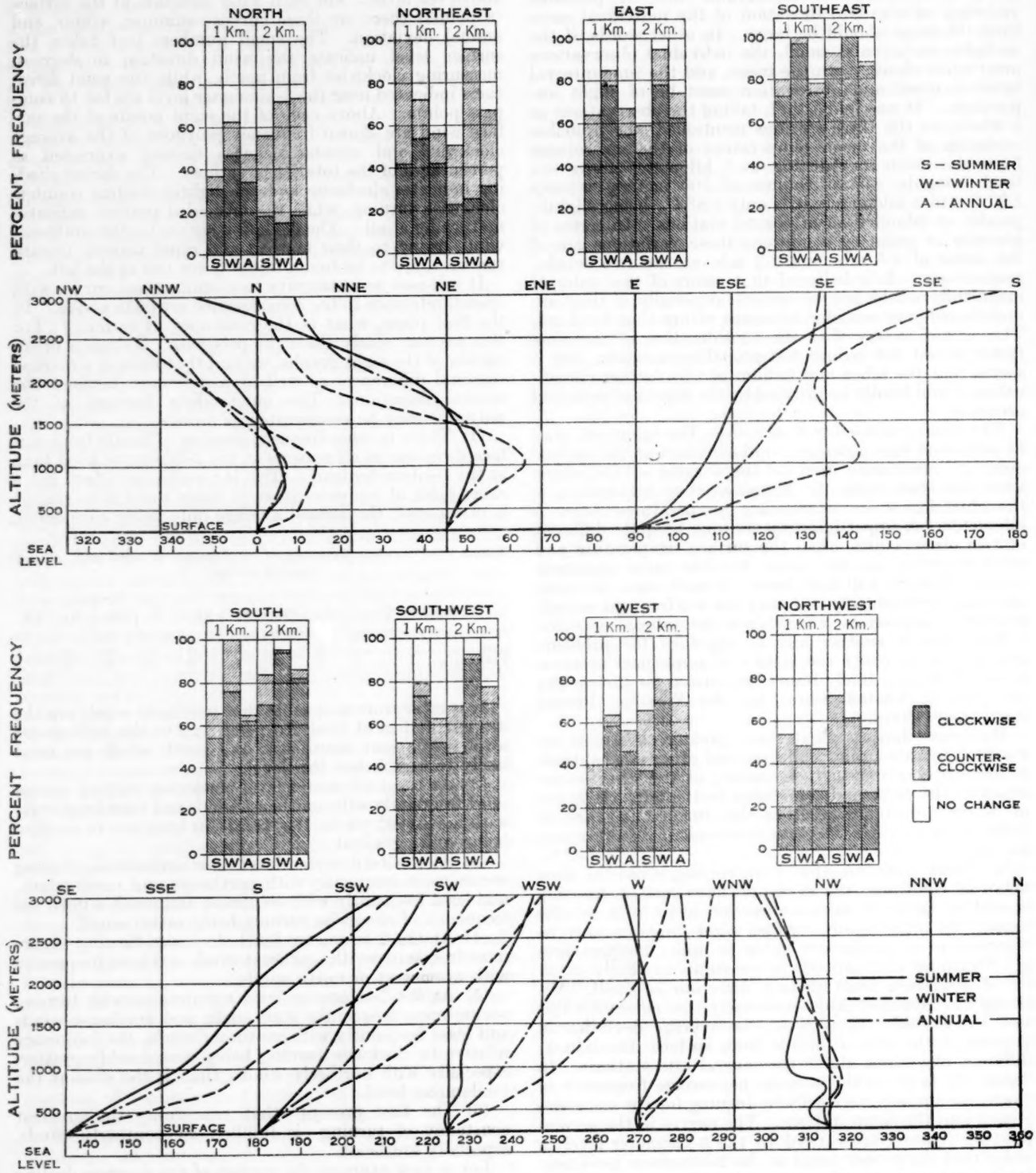


FIG. 1.—Summer, winter, and annual average turning of winds with altitude from the eight surface directions, and the percentage frequency of clockwise and counterclockwise turning.

discussed above. The following features appear worthy of consideration:

(1) At the 1-kilometer level all winds except northwest deviate clockwise. With northwest winds the winter deviation is clockwise also by a very small amount, but the summer and annual curves tend counterclockwise.

(2) At the 1-kilometer level the maximum deviation in the clockwise direction occurs with east and southeast winds. In winter this deviation amounts to more than 45°.

(3) At the 1-kilometer level the clockwise deviation is much less in summer than in winter; with northwest winds, mentioned in (1), the summer deviation is counterclockwise.

(4) At the 2-kilometer level all winds, excepting north, northeast, and northwest, deviate clockwise; in the three exceptions the deviations are decidedly counterwise.

(5) At the 2-kilometer level the maximum clockwise deviation occurs with southeast winds, where, in winter, it amounts to as much as 75°.

(6) At the 2-kilometer level the maximum counterclockwise deviation occurs with northeast winds, where, in winter, it amounts to about 30°.

(7) At the 2-kilometer level the clockwise deviation is more pronounced in winter than in summer. This is also true in the case of the three northerly winds mentioned in (4) with respect to counterclockwise deviation.

(8) The second precept—that concerned with the occurrence of the smallest average deviation—is fulfilled with the northwest wind.

It thus appears that the earlier contention that wind direction is a reliable index to upper temperatures is verified by these considerations. It was seen from the frequency polygons that the turning is most frequently the same aloft when the winds are southerly, but that the average deviation from surface direction is least when the winds are northerly. *The greatest average deviation occurs with greatest reliability of turning; the least deviation occurs with the least reliability of turning.*

The conclusion is, therefore, that the available statistical evidence is decidedly favorable to the use of surface wind direction in the capacity of an index to the thermal conditions aloft.

THE EVALUATION AND GEOGRAPHICAL DISTRIBUTION OF Δ.

The data.—The collection of data consisted in going over the individual kite flights and determining the mean temperature of the air column, finding its difference from the surface temperature, and classifying this difference by wind direction (eight points) and by months. The record sheets of the flights prepared in the Aerological Division of the Weather Bureau give the conditions of temperature, pressure, vapor pressure, etc., at frequent altitude stages, and the simultaneous surface conditions. In determining the mean temperature of the air column between the surface and a chosen level, say 1 kilometer above sea level, it was necessary to weight the mean temperatures of several layers intervening according to the depth of each layer. In this way, the mean temperature of the required air column was the weighted mean of several layers whose mean temperature could be very accurately determined. Inspection of the vertical curves of temperature indicates that, when carefully performed, this method of integration is sufficiently accurate.

Definition of Δ.—Experience has indicated that confusion may arise in the use of the rather prolix expression "difference between the mean temperature of the air column and the surface temperature," a phrase that has been used a great deal. A symbol for this quantity is desirable since it will be necessary to refer to it again and again. Consequently from the following relation,

$$t+\Delta=\theta,$$

in which t represents the surface temperature, θ the mean temperature of the air column, and Δ the difference between the two, it appears that Δ will fulfill this need satisfactorily.[16] It has been used throughout the paper.

The aerological stations.—The data were drawn from the seven kite stations of the Weather Bureau, two of which have since been discontinued. They comprise four stations in an approximately north-south line in the Middle West—Ellendale, N. Dak.; Drexel, Nebr.; Broken Arrow, Okla.; and Groesbeck, Tex.;—a station at Royal Center, Ind.; one at Leesburg, Ga.; and one at Mount Weather, Va. The last two stations are no longer in operation, the former having been replaced about the end of 1920 by one more satisfactorily located at Due West, S. C., and the latter discontinued in 1914, after seven years of active work. The preliminary studies were concerned only with Mount Weather, Ellendale, and Drexel, but the present paper has been based upon all flights occurring about 8 a. m., 75th meridian time, at all stations up to the beginning of 1921. The data at Due West have not been considered because this station has been established so recently that the means of the difference between the surface temperature and the mean temperature of the air column would not be very reliable. Moreover, Due West affords an interesting opportunity to test the accuracy of the computed pressure maps.

The total number of kite observations examined and tabulated is over 5,000 when all stations are considered. It is seen that even when this number is subdivided and apportioned to the several stations and further divided by classification into months and wind directions the numbers of observations upon which the means are based are large enough to justify a considerable degree of confidence. For some wind directions the number is larger than for others, but, fortunately, in such cases the number of observations is a fair index of the frequency of occurrence of such winds, and the low reliability of certain values is offset statistically by the paucity of occurrences.

The reduction levels.—Two free-air levels, 1 and 2 kilometers above sea level, respectively, were chosen. There are several reasons why these particular levels seemed most desirable, namely, (1) the largest amount of aerological data was available for these lower levels, since the number of kite flights that reached altitudes greater than 2 kilometers above sea level falls off rapidly; (2) it is at about these levels that the greatest amount of flying takes place, hence maps of pressure there would be of the greatest benefit to aviators; and (3) above 2 kilometers the

[16] A clear distinction should be made by the reader between the term Δt commonly used in aerology and the symbol Δ used in this paper. The former is a symbol used to denote the *rate of change of temperature with altitude*. It is called the vertical temperature gradient or lapse rate and usually is the amount of temperature change per altitude change of 100 meters. Its sign is *positive* when temperature *falls* with increase of altitude and *negative* in the case of *inversion*. The following quotation from the recommendation of the Subcommission on International Publications at Monaco, in 1909, gives the basis for this usage:

"La Sous-Commission recommande d'adopter, pour la définition du signe du gradient vertical de la température, le systeme ou le gradient sera positif lorsque la température diminue à mesure que la hauteur augmente, et que le gradient sera négatif dans la cas contraire." (*Sixième Reunion de la Commission Internationale pour l'aerostation scientifique à Monaco du 31 mars au 6 avril, 1909.* Strasbourg, 1910.)

On the other hand, the symbol Δ does not represent a lapse *rate*: it represents an accual *difference of temperature* between two points in a vertical in the atmosphere, one at the surface and the other in the free air at a level representative of the air column in question. Hence, when the temperature *falls* with altitude, the value of Δ is *negative*, and when temperature *rises* the sign is *positive*. Owing to this difference of sign, it is imperative that Δt and Δ be not confused.

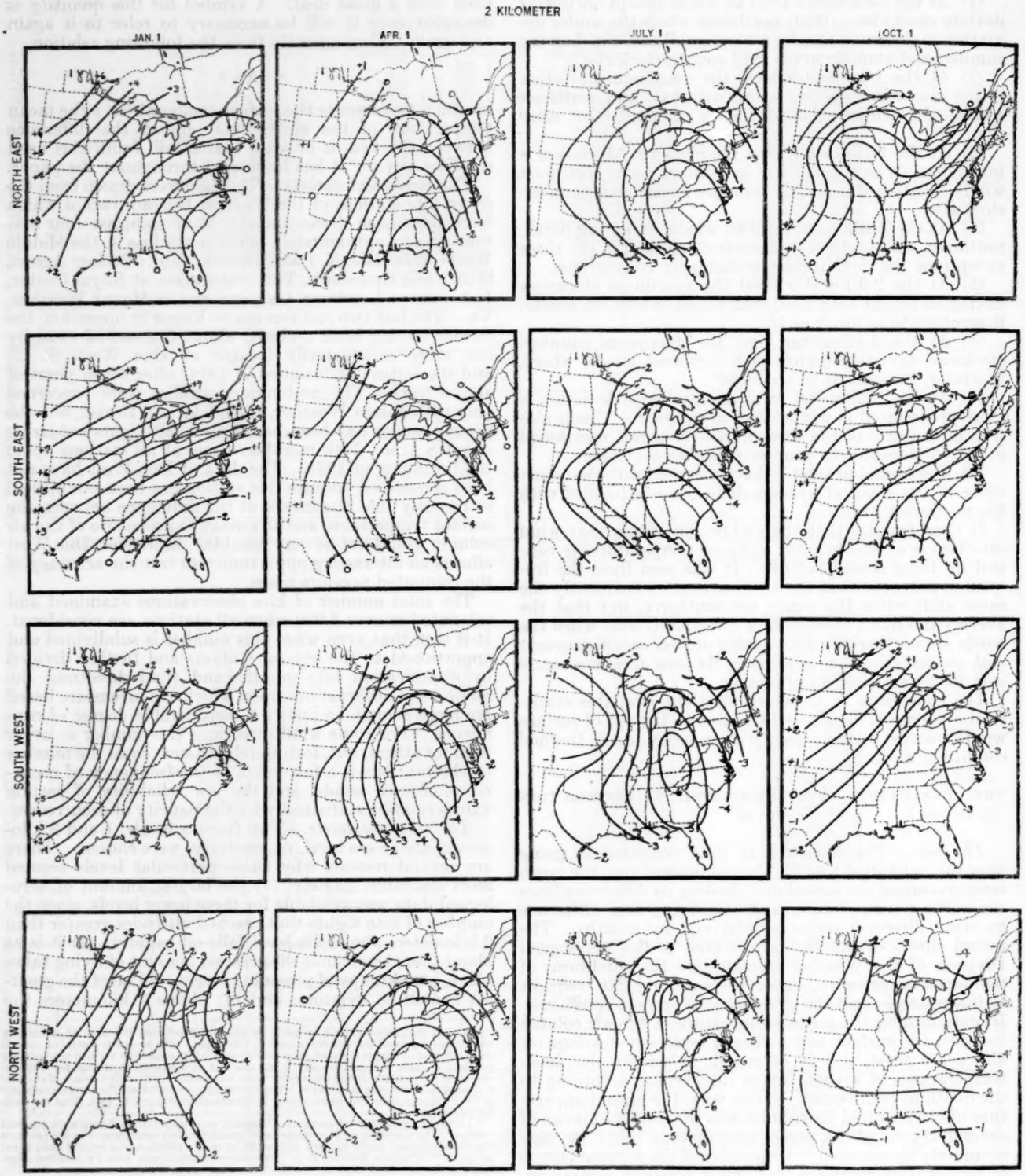


FIG. 2.—Specimen charts of the distribution of Δ at 2 kilometers

tendency for isobars to lie prevailingly from west to east becomes apparent. The weaker pressure formations may not extend above that height, yet they may have a profound influence upon the surface weather.

Below 1 kilometer, the effect of surface-induced turbulence may, and does, have considerable influence in deflecting winds from the gradient direction and in preventing them from attaining gradient speed. Thus, the 1 and 2 kilometer levels seem acceptable as trial levels for pressure reductions.

The time of observation.—In selecting the flights from which the data were obtained, an attempt was made to take only those representative of conditions about 8 a. m., 75th meridian time. The average time of kite flights at various aerological stations is about 10 a. m., but flights occurring much later or much earlier than 8 a. m. were not included in this study. The purpose in using only those observations was to get temperature relations that would be applicable to the regular morning observations at Weather Bureau stations. Therefore, while it is undoubtedly true that the mean time of the observations contained herein is not precisely 8 a. m., it must lie within a few minutes of that time, and, for all practical purposes, the change in temperature owing to this time difference would be negligible.

Owing to the small number of flights occurring during the evening hours, no attempt has been made to prepare similar data for the 8 p. m. observation. Work must, however, be done along this line, possibly as the next step in this research.

Treatment of original data.—The data, after being compiled as indicated above, were modified so as to include the thermal effect of mean monthly vapor pressure and smoothed graphically by means of lines showing equal values of Δ on coordinates of surface wind direction and months. This was done for each level and for each of the kite stations. The smoothed values of Δ were then plotted on maps of the eastern United States and lines of equal value of Δ were drawn, thus showing the geographical distribution. Figure 2 shows some of these maps. From such charts it was possible to interpolate for intermediate reporting stations of the Weather Bureau.

The selection of stations.—An attempt was made to select about 30 regular Weather Bureau stations having good anemoscope exposures. It must be confessed that this was difficult. The location of wind vanes on high buildings in large cities where they are affected by eddies caused by surrounding buildings or architectural features not infrequently renders the recorded wind direction at variance with the direction at surrounding stations and the general flow indicated by the isobars. Again, certain anemoscope exposures are not comparable with those at surrounding stations because of topographic irregularities, valleys, slopes, etc., which deflect the vane from the direction the pressure gradient requires. Perhaps there have been included in this list some that are not the best from this viewpoint.

Another qualification, however, is that they shall be rather evenly spaced about the country within the limits deemed safe for interpolation. The following table gives a list of the 32 stations selected, their altitudes above sea level, and the length of the air column to the two reduction levels:

TABLE 2.—*The stations, their altitudes and distances from the two reduction levels (meters).*

Station.	Altitude above m. s. l.	Length of air column to—	
		1 km. above m. s. l.	2 km. above m. s. l.
Albany, N. Y.	30	970	1,970
New York, N. Y.	96	904	1,904
Washington, D. C.	34	966	1,966
Norfolk, Va.	28	972	1,972
Wilmington, N. C.	24	976	1,976
Columbia, S. C.	107	893	1,893
Jacksonville, Fla.	13	987	1,987
Atlanta, Ga.	358	642	1,642
Thomasville, Ga.	83	917	1,917
Pensacola, Fla.	17	983	1,983
Anniston, Ala.	226	774	1,774
Vicksburg, Miss.	75	925	1,925
New Orleans, La.	16	984	1,984
Houston, Tex.	42	958	1,958
Little Rock, Ark.	109	891	1,891
Memphis, Tenn.	121	879	1,879
Nashville, Tenn.	166	834	1,834
Lexington, Ky.	301	699	1,699
Indianapolis, Ind.	250	750	1,750
Columbus, Ohio.	250	750	1,750
Pittsburgh, Pa.	257	743	1,743
Buffalo, N. Y.	231	769	1,769
Port Huron, Mich.	194	806	1,806
Duluth, Minn.	345	655	1,655
Moorhead, Minn.	286	714	1,714
Madison, Wis.	297	703	1,703
Des Moines, Iowa.	262	738	1,738
St. Louis, Mo.	173	827	1,827
Yankton, S. Dak.	376	624	1,624
Concordia, Kans.	424	576	1,576
Oklahoma City, Okla.	370	630	1,630
Abilene, Tex.	530	470	1,470

Figure 3 shows the distribution of the interpolated reporting stations which were used as reduction points in the maps that follow.

TESTING THE METHOD.

The nature of the tests.—Before proceeding with the values of Δ deduced in the foregoing pages to the actual making of upper maps, it is desirable to subject the scheme to as many tests as possible. It is practically impossible at the present time to know the absolute synchronous pressure distribution at free-air levels; hence comparisons of pressures computed by this method with those actually existing are difficult. But three methods of approaching such tests suggest themselves, the first being direct while the second and third are indirect but dependent upon well-known and theoretically sound physical relations. These methods are:

(1) The comparison of computed pressures with those actually measured with kites. The Due West, S. C., station was inaugurated so recently that it was impossible to include in the data of this paper observations from that station. Such values of Δ as may be applied to Due West must be interpolated from the maps of the previous chapter and are in no way influenced by actual observations at that point. If, then, such interpolated values of Δ yield temperature arguments giving computed pressure in good agreement with those observed, the method may be regarded as satisfactory.

(2) Having made maps based upon observed free-air wind velocities and gradient wind relations, it is now possible to make comparison maps computed from surface data. If the two maps agree, confidence in both will be increased.

(3) On certain days when widespread pilot-balloon observations were made up to 2 kilometers it was possible to prepare computed maps for the 1 and 2 kilometer levels and, upon the basis of the gradient wind relations, to compare the observed direction and speed of the wind with the trend and spacing of the isobars.

Computations for Due West, S. C.—Considering the first plan, the procedure for comparing computed with observed pressure values as obtained by the meteorograph at Due West was as follows:

(1) The aerological records of 42 kite flights made at about 8 a. m. and reaching the 2-kilometer level were selected at random except that a general seasonal distribution was sought. These 42 flights were made between March 6, 1921, and January 11, 1922.

(2) The surface data at the beginning of the flights were the bases for the computations and consisted of wind direction, pressure, and temperature. These were tabulated, together with the observed pressures, for the 1 and 2 kilometer levels.

(3) Values of Δ interpolated from the maps were applied to the surface temperature and the pressure at the upper level computed by the hypsometric formula.

The average difference for the 1-kilometer level was -0.5 mb. and for the 2-kilometer level -1.4 mb. This average difference, it will be noted, is negative, indicating that the computed pressure is, on the average, too low. The following effects may account for such a tendency:

(1) Change of pressure at upper levels between the time of kite launching, or, more precisely, the epoch of the computation, 8 a. m., and the time of the arrival of the kite at upper levels. This may be the result of irregular variations of pressure due to the approach or recession of cyclonic areas, or the diurnal variation of pressure, or both. These effects were estimated at 0.2 mb. and 0.3 mb., respectively, for the 1 and 2 kilometer levels; and, being of the proper sign, when applied to the average differences above, decreased them to -0.3 mb. and -1.1 mb. for the two levels respectively.

(2) Change of pressure at upper levels during the interval mentioned in (1) resulting from the diurnal change of temperature in the low levels of the atmosphere. This effect was estimated at 0.1 mb. and 0.2 mb. for the two levels, respectively, and further decreased the outstanding difference to -0.2 mb. and -0.9 mb., respectively.

(3) The residual negative tendency is small enough to exert but little effect upon the whole map when it is considered that the isobars will be drawn for intervals of 2.5 mb., horizontal difference of pressure. Moreover, such tendencies will probably not be localized at certain stations but will, in general, be operative over considerable areas, with the result that the horizontal gradients of pressure will be but little affected. It is the gradient rather than the absolute pressure that is of chief concern.

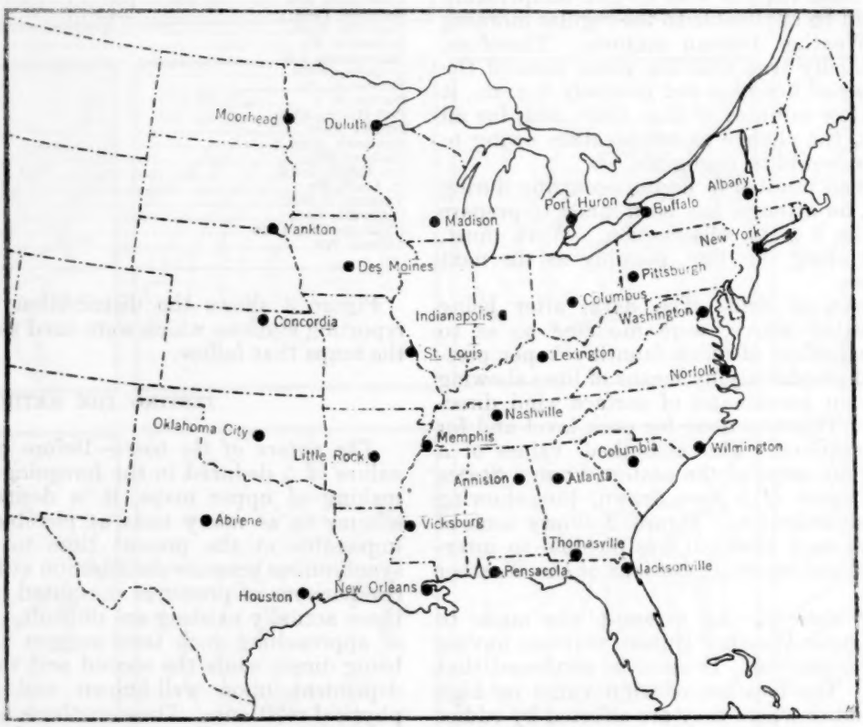


FIG. 3.—Reduction stations employed in the study.

Pressure mass from observed wind velocities.—From the gradient-wind equations it is possible to compute the velocity of the gradient; latitude, density, and radius of curvature of wind path are known. Conversely, if the gradient dp/dn is unknown, but the speed of the wind is observed by kite or pilot balloons, it is possible to solve the equations for the gradient. If this is done for a number of stations, the distance between isobars can be computed and the distribution of pressure at the upper level determined, the trend of the isobars being indicated by the observed wind directions. A few kite flights reaching the required levels enable one to assign actual values to the isobars, thus completing the map.

In 1920, as a matter of interest, this was done.[17] Figures 4, 5, and 6 show, respectively, the barometric situation at 8 a. m., March 27, 1920, at sea level, 1 kilometer, and 2 kilometers above sea level. These maps are reprinted from that article. The wind arrows show the directions from which the trend of the isobars was determined. At that time it was impracticable to compute the pressure at the upper levels in any other way; with the completion of the tables of Δ, however, it is now possible to compute a map for the same date and time based only upon surface conditions. The similarity of the two sets of maps thus independently arrived at indicates not only that both are substantially correct but also that the Δ-method of computing pressures is reliable.

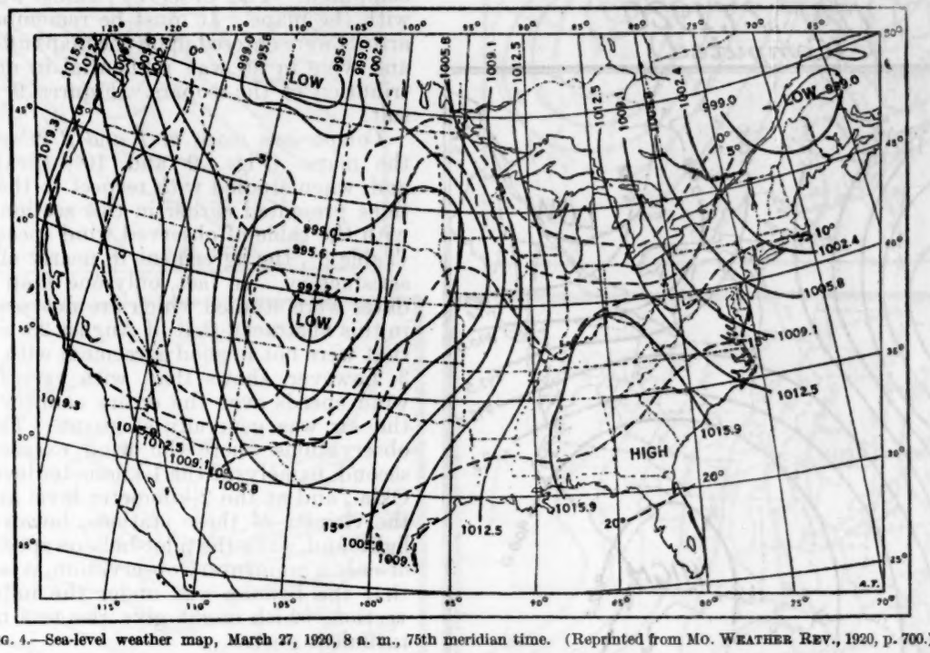


FIG. 4.—Sea-level weather map, March 27, 1920, 8 a. m., 75th meridian time. (Reprinted from MO. WEATHER REV., 1920, p. 700.)

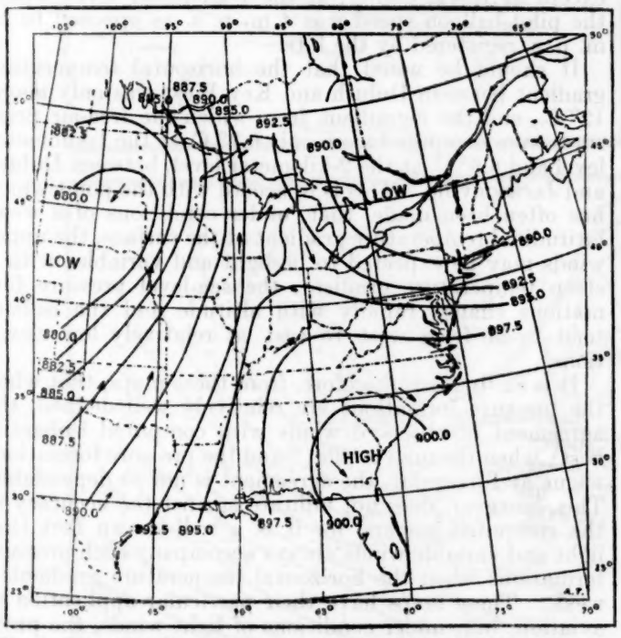


FIG. 5.—Pressure at 1 kilometer above sea level, in millibars, March 27, 1920, 8 a. m., 75th meridian time. (Reprinted from MO. WEATHER REV., 1920, p. 700.)

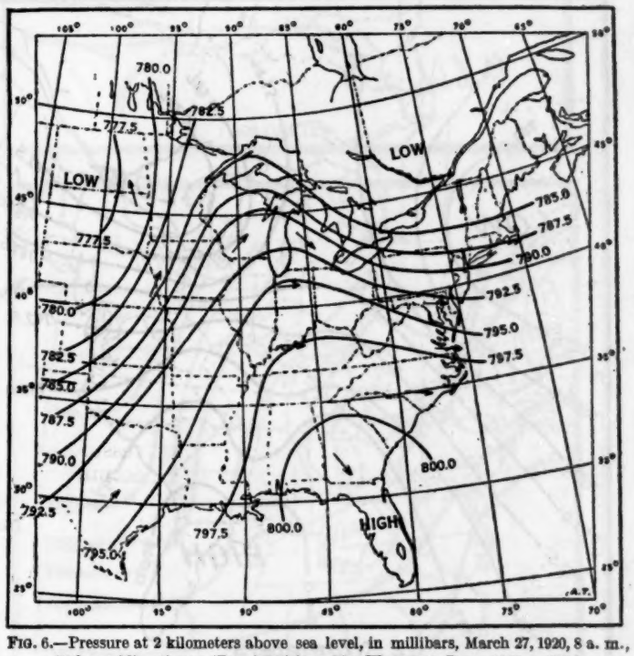


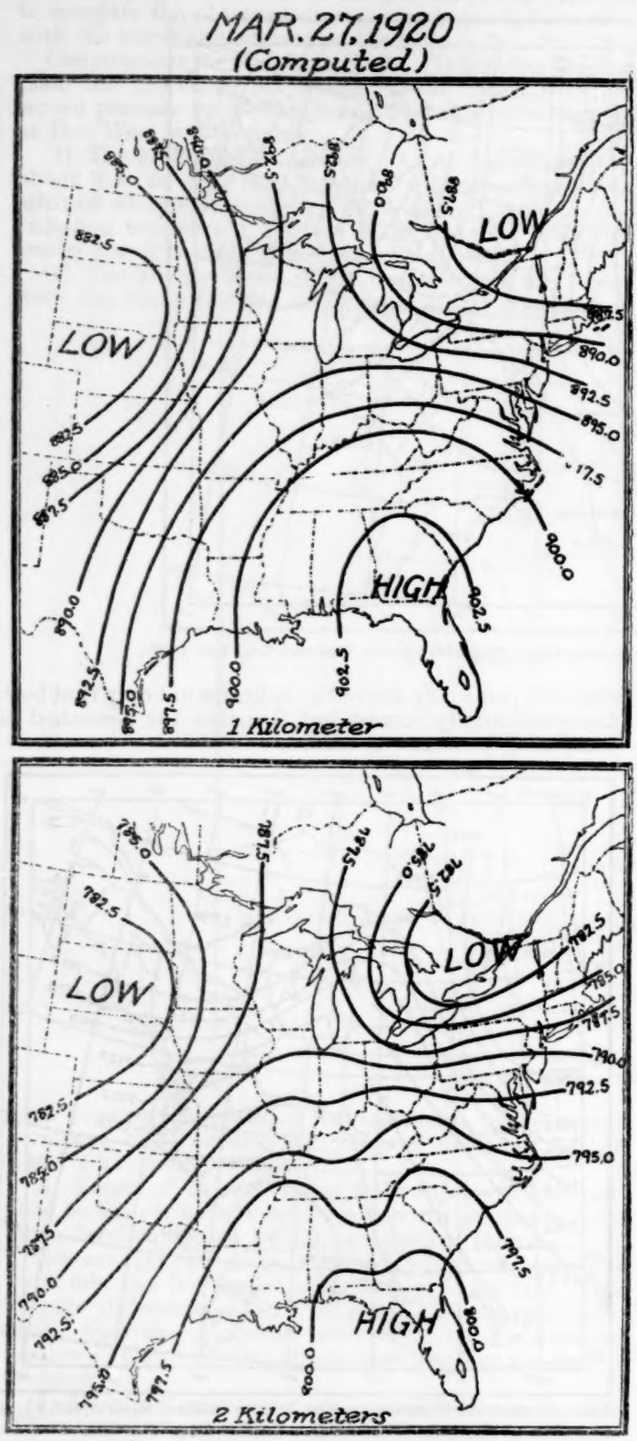
FIG. 6.—Pressure at 2 kilometers above sea level, in millibars, March 27, 1920, 8 a. m., 75th meridian time. (Reprinted from MO. WEATHER REV., 1920, p. 700.)

The reader is therefore invited to compare Figures 5 and 6 with figures 7 and 8. It is needless to say that the agreement is striking.

Computed maps and observed winds.—In line with the above idea is that of drawing free-air pressure maps by

[17] Meisinger, C. Le Roy: The making of upper-air pressure maps from observed wind velocities. MO. WEATHER REV., Dec., 1920, pp. 697-701.

computation alone, and then comparing them with free-air wind observations at as many stations as possible. This is substantially the same idea as that employed above, except that no map is drawn from the observed wind velocities.



FIGS. 7–8.—Pressure distribution at 1 and 2 kilometers above sea level, March 27, 1920, 8 a. m., 75th meridian time, computed from surface data.

The Aerological Division, from an inspection of its records, supplied a list of dates when widespread pilot-balloon observations were made at the several stations of the Weather Bureau, the Signal Corps, and the Navy. Pressure maps, based entirely upon surface data, were computed. The observed winds were then compared with the maps. It must be remembered that the wind arrows were entered upon the maps *after* they were drawn, and were in no way influential in determining the distribution of the isobars. Figures 9 to 10 show the result.

Comparison maps at 1 and 2 kilometers.—In general, the maps (Figs. 9 and 10) speak for themselves, and, when studied with respect to the various considerations presented earlier in this section and in connection with the table of observed wind speeds at the two levels (Table 3), the agreement in nearly all cases is strikingly satisfactory. In fact, only one map (several additional dates were studied which are not presented graphically in this abstract), that of August 23, showed wind arrows that were not in good agreement with the isobars. Table 3, however, shows that, with very few exceptions, the wind speeds over the entire country were low; in fact, the air was generally stagnant. There were only two observations where the wind exceeded 10 meters per second, namely, at the 1-kilometer level at Broken Arrow, Okla., and at the 2-kilometer level at Lee Hall, Va. In the vicinity of these stations, however, the winds were light, and, since the pilot-balloon speed is really the result of only a momentary observation, it is altogether possible that the balloon was under the influence of local convection, which might give rise to a momentary lurch or turbulent gust.

Kite flights were made at the same time at Ellendale, Drexel, Broken Arrow, and Royal Center. At all places, the direction given pilot balloons and kites is in substantial agreement, and the same can be said of the speed, except at Royal Center, at the 1-kilometer level, where the pilot-balloon speed was 4 m. p. s. as opposed to 10 m. p. s. registered by the kite.

It should be noted that the horizontal temperature gradient between Duluth and Key West was only about 12° C., and the θ-gradient from which the free-air pressures were computed were only 6.7° C. at the 1-kilometer level and 8.6° C. at the 2-kilometer level, between Duluth and Jacksonville. This is in accord with the point which has often been made, that, under conditions of a week latitudinal temperature gradient at the surface, the upper winds may be expected to be light and variable; with a steep temperature gradient, the sea-level pressure formations change rapidly with altitude and the isobars tend to lie from west to east at relatively low elevations.

It is easily seen, therefore, from these maps, that when the pressure formations are relatively well defined, the agreement of observed winds with computed isobars is best; when the map is "flat" and the pressure formations vague and irregular, the agreement is not so dependable. This, however, does not militate against the accuracy of the computed isobars, for it is a well-known fact that light and variable winds always accompany such pressure formations when the horizontal temperature gradient is weak. These maps have their particular application to aviation, but, under conditions of light winds, the problem of aerial navigation is correspondingly simplified. On such stagnant summer days, the aviator is more concerned with the vertical component of the air than the horizontal. On August 28, 1921, there was probably not a single section east of the Mississippi and Ohio Rivers where the wind speeds were of sufficient magnitude to be a factor in the navigation of either lighter-than-air or heavier-

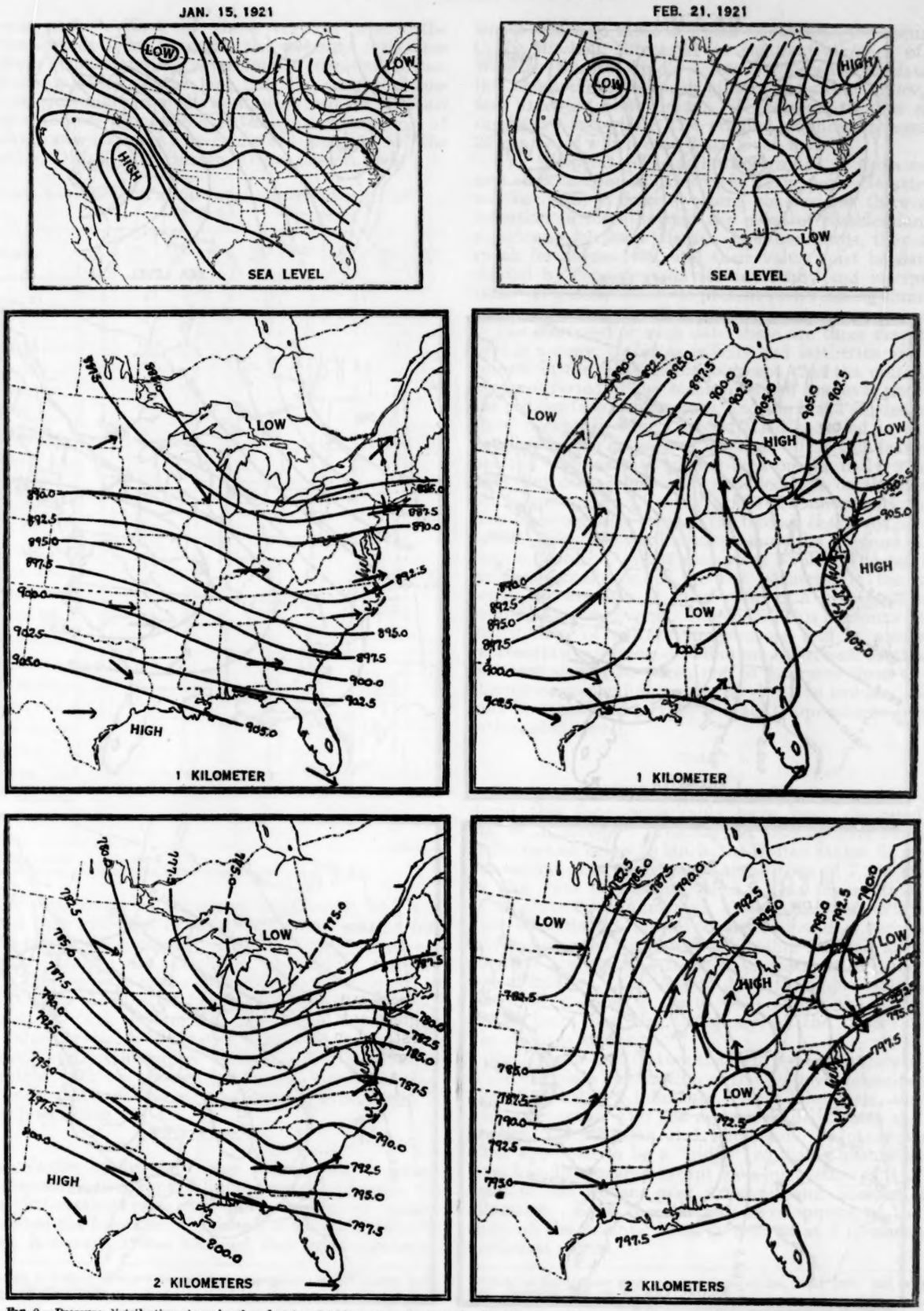


FIG. 9.—Pressure distribution at sea level and at 1 and 2 kilometers above sea level on January 15, 1921, and February 21, 1921, compared with winds observed at aerological stations.

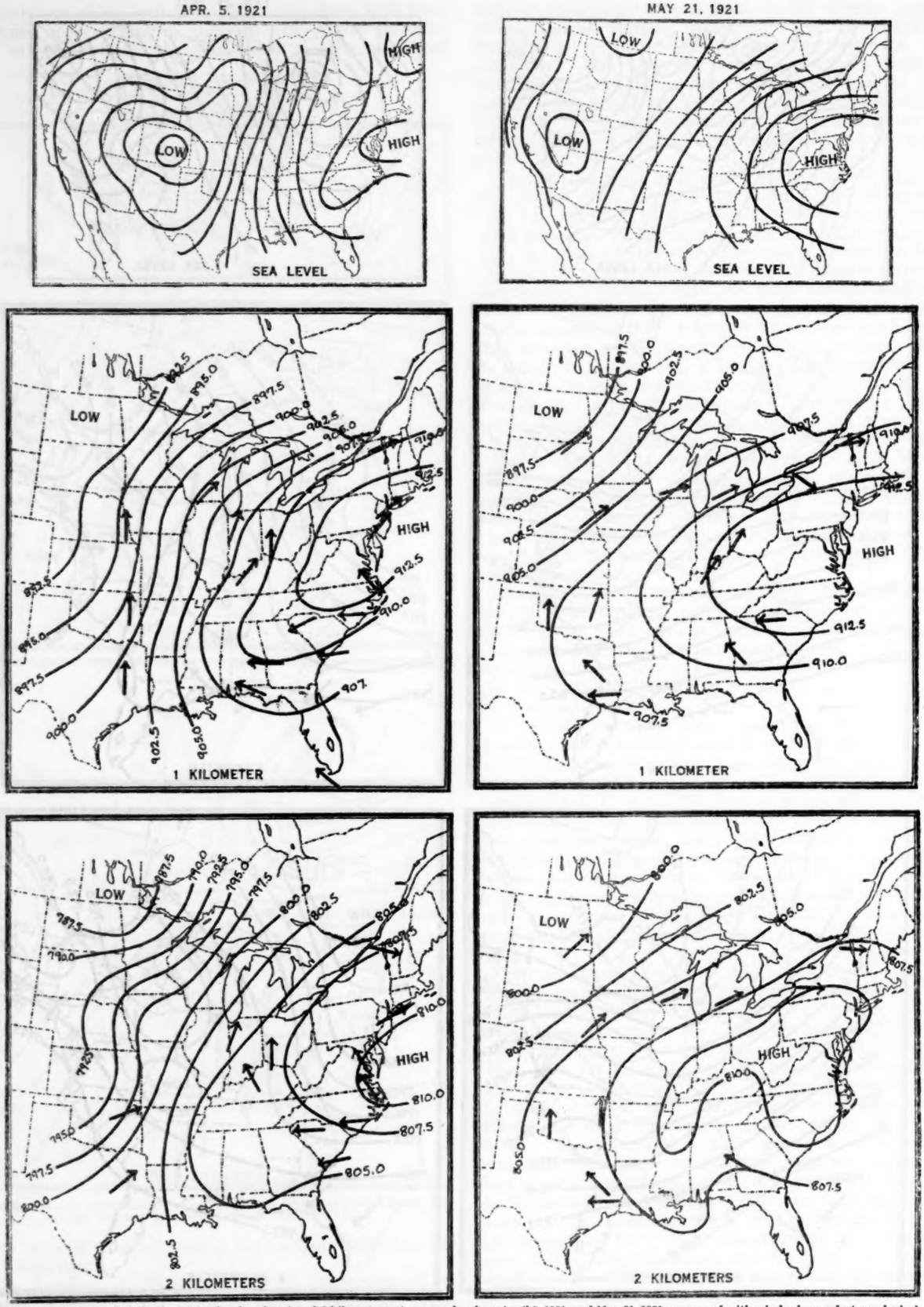


FIG. 10.—Pressure distribution at sea level and at 1 and 2 kilometers above sea level on April 5, 1921, and May 21, 1921, compared with winds observed at aerological stations.

than-air craft.[18] West of these regions, where the observed winds were stronger, the pressure formation was more definite and the agreement in direction better. Attention is called to the fact that the tongue of low pressure protruding from the Southwest into the Missouri Valley was more pronounced at the upper levels than at sea level, and its reality is confirmed strongly by the Ellendale, Drexel, and Broken Arrow observations.

TABLE 3.—*Velocities of observed winds at pilot balloon stations (m. p. s.).*

Station.	Km.	Jan. 15.	Feb. 21.	Apr. 5.	May 21.	July 8.	July 8.	Aug. 23.	Sept. 26.
Burlington, Vt.	1	9	7	9	13	5	3	.....	.....
	2	.....	8	11	12	7	3	.....	.....
Ithaca, N. Y.	1	12	6	3	8	17	3	.....	.....
	2	.....	4	.....	8	21	5	.....	.....
Mitchell Field.	1	12	9	11	.....	.....	.....	3	11
	2	.....	10	7	.....	.....	.....	5	16
Lakehurst, N. J.	1	.....	.....	8	.....	.....	.....	.....	.....
	2	.....	.....	2	.....	.....	.....	.....	.....
Washington, D. C.	1	.....	10	4	1	5	2	5	9
	2	.....	7	5	2	10	2	7	12
Lee Hall, Va.	1	13	.....	5	1	6	4	9	2
	2	.....	.....	10	1	10	1	13	.....
Camp Bragg, N. C.	1	6	.....	8	4	7	3	7	.....
	2	.....	.....	8	.....	5	2	7	.....
Due West, S. C.	1	.....	.....	12	5	10	2	5	3
	2	.....	.....	8	.....	2	3	4	2
Parris Island, S. C.	1	16	10	10	.....	.....	.....	.....	.....
	2	20	.....	6	.....	.....	.....	.....	.....
Key West, Fla.	1	14	3	7	.....	5	10	2	5
	2	29	.....	1	.....	5	8	4	4
Pensacola, Fla.	1	18	8	9	.....	9	7	7	4
	2	25	.....	.....	.....	5	.....	9	3
Camp Benning, Ga.	1	17	.....	12	8	5	.....	8	4
	2	23	.....	2	.....	5	.....	2	5
Camp Knox, Ky.	1	11	.....	7	8	8	15	5	.....
	2	.....	.....	7	4	11	10	5	.....
McCook Field, Ohio.	1	.....	8	5	5	.....	10	1	5
	2	.....	8	5	3	.....	8	3	4
Royal Center, Ind.	1	.....	4	12	3	7	9	[1] 4–10	8
	2	.....	6	14	2	3	10	6	2
Lansing, Mich.	1	.....	5	.....	5	8	7	.....	.....
	2	.....	6	.....	7	4	14	.....	.....
Madison, Wis.	1	7	9	18	13	4	10	.....	.....
	2	14	11	.....	7	3	8	.....	.....
Ellendale, N. Dak.	1	13	3	.....	9	.....	8	[1] 6–7	14
	2	18	8	.....	8	.....	8	[1] 9–10	14
Fort Omaha, Nebr.	1	.....	9	15	20	.....	7	[2] 5	14
	2	.....	.....	.....	12	.....	12	[2] 1	.....
Broken Arrow, Okla.	1	13	8	19	12	15	5	[1] 16–15	.....
	2	20	11	15	5	.....	10	[1] 2– 5	.....
Groesbeck, Tex.	1	8	8	13	8	.....	10	5	7
	2	17	14	17	9	.....	8	5	8
Fort Sill, Okla.	1	.....	.....	.....	13	11	4	.....	.....
	2	.....	.....	.....	11	.....	11	.....	.....
Ellington Field, Tex.	1	.....	10	.....	12	.....	.....	.....	5
	2	.....	21	.....	12	.....	.....	.....	3
Kelly Field, Tex.	1	8	9	.....	.....	6	4	5	3
	2	8	17	.....	.....	.....	6	9	2

[1] Kite observation.
[2] Kite observation at Drexel, Nebr., about 20 miles west of Fort Omaha.

These tests could be continued indefinitely, but it is believed that sufficient evidence has been brought forward to justify the conviction that these free-air maps are accurate. Are we not, therefore, justified in carrying on? If the answer is in the affirmative, we are obliged to give the maps the most thorough study possible in order to ascertain their value for day-to-day forecasting. Their value in relation to aviation is unquestioned, and, if the example of the Japanese meteorologists is to carry any weight with us, we can not escape the belief that these daily charts of free-air conditions will be useful in general forecasting.

THE MAPS.

The selection of dates for map drawing.—It is manifestly impossible to cover in a limited number of maps, the myriad interesting cases in which capricious nature checkmated the forecaster. Instead of selecting dates at random, however, it was believed that greater interest would attach to those in which the unexpected occurred. C. L. Mitchell, forecaster at the central office of the Weather Bureau, kindly selected a long list of dates of this character from which all the maps that follow, the first excepted, were drawn. These seem to offer much suggestive material. The original publication contains 22 charts, of which only 8 are given here.

The viewpoint.—The following groups of maps represent the culmination of effort in this paper. No attempt will be made to draw sweeping conclusions; there is no intention to force beyond the point of justification the significance of these charts. In other words, they must speak for themselves, and their value must be demonstrated by consistent day-to-day study and interpretation. It is desired only to present such running comment as seems pertinent and suggestive.

The charts.—For each date there are three maps; the first is a copy, so far as isobars and isotherms are concerned, of the weather maps except that the units have been converted. The black lines are sea-level pressure, the red, surface temperature, and the black shaded areas show regions in which precipitation occurred in the 24 hours *following the time of the map.* This last feature is not the same as that shaded area on the daily weather map, but corresponds to the shaded area on the map of the following day. This is for use in connection with the possible prognostic value of the free-air charts for precipitation. The two smaller maps show the pressure distribution, in black, at the respective levels. The red lines on these smaller maps are not isotherms in the usual sense, but are lines of equal value of θ or lines of equal temperature argument. In general, this conforms to the distribution of surface temperature and is somewhat representative of the distribution of free-air isotherms, but care should be taken not to interpret them as isotherms corresponding to the level of the isobars. They may be considered as approximate temperatures at some intermediate level.

CHART 1.

December 17, 1919.—The especial features which rendered this date remarkable have been discussed by Mr. W. R. Gregg.[19] The highest velocity ever observed in the free air below 10 km. in the United States, 83 meters per second, was observed at an altitude of 7,200 meters on this date at Lansing, Mich. This observation was corroborated by numerous observations of extremely high velocities at the levels reached and a very rapid increase of speed with altitude at other stations, although no other observations reached so great an altitude. It was of interest, therefore, to draw the upper isobars for this date in order to see to what extent the computed isobars bore out the testimony of the observations. The result is striking.

Perhaps the first feature that will appear to the student is the complete obliteration of the sea-level pressure configuration below 1 kilometer. At 2 kilometers, the isobars are parallel over the eastern United States and the gradient steeper than at 1 kilometer. In other words, what appeared to be a "ridge" of high pressure at sea level has disappeared except for a suggestion of it in the bend of the isobars over Arkansas and Missouri at 1 kilometer. Even the southern development of the cyclone on the Atlantic coast is overrun at 1 kilometer by northwest winds.

[18] Meisinger, C. LeRoy: The weather factor in aeronautics. Mo. WEATHER REV., December, 1920, pp. 701–708.

[19] Note on high free-air wind velocities observed Dec. 16–17, 1919. Mo. WEATHER REV., December, 1919, pp. 853–854.

The reason for this sudden change within a small limit of altitude is not hard to find. It lies in the marked gradient of surface temperature which is accentuated and somewhat smoothed in the 1-kilometer distribution of θ. It is clear that the temperature distribution and not the surface pressure was the dominating influence on this day. The wind, in attempting to flow from above the warm region to the cold region was deflected by the earth's rotation with the result that it flowed nearly parallel to the isotherms.

The forecaster doubtless would have forecast westerly winds at a quite low elevation, but it is a question whether he would have anticipated that opposing winds at ordinary flying levels between New York and Chicago would have a force approximately equal to half the air speed of a commercial airplane. Or that a high-powered commercial dirigible flying the same route would have had its speed reduced to less than that of an express train. Or that the same craft flying from Chicago to New York would have been able to arrive at the destination several hours sooner than usual. These are facts of the greatest importance in the dispatching of mail and will be of greater importance as the activities of commercial aviation multiply. Free-air maps disclose the facts without surmise or guess.

CHARTS II–III.

March 14–15, 1919.—Preceding the first day of this period, a low pressure area had traveled along a curved path from the middle of the Oregon coast to the point in the northern part of Colorado, where it is seen on the sea-level map (Chart II). A well-marked high-pressure area is found over Ontario, and between the high and low centers lie evenly spaced isobars representing a difference of pressure of about 54 mb. The direction of movement of the low center is of chief interest in this series. Judging from the forecasts of colder in the west portions of Nebraska and South Dakota for the following day, it was apparently anticipated that the cyclone would move more to the east than it actually did. In fact, as the map for the 15th shows, the north component of motion exceeded that of the east component and the center appeared in north central North Dakota (Chart III). The map for the following day does not extend far enough north for one to ascertain the location of the lowest pressure, but it is not unlikely that it lies in a general line with the direction of the previous day. This motion was from a little south of southwest. The sea-level isobars the first day had a trend from southeast to northwest over the eastern United States, the second day more from the south, the third day from the southwest. What do we find aloft?

On the first day, instead of high pressure so far to the north as pictured at sea level, it appears more as a general high pressure region east of the United States producing winds at 1 kilometer below latitude 40° from the south-southwest and north of that latitude from the southeast. At 2 kilometers, the isobars are from the seuthwest. With general high pressure to the east and a well-defined isobaric trend from south-southwest to north-northeast at 2 kilometers, it is quite apparent that the movement of the cyclonic center is definitely related. The 15th shows this southwest current still better established and, judging from the closer isobars, of higher velocity. The direction of movement of this center throughout the period is parallel to these isobars. The developing "wall" of high pressure in the free air extends parallel to the Atlantic coast—a fact not discernible on the sea-level map. The progressive northward bulging of the θ-isotherms shows the effect of the importation of warm, southerly air.

It is apparent here, as it will be in later maps, that sea-level anticyclones, at least in winter, are not reproduced in the free air with the positiveness characteristic of cyclones. The Colorado cyclone, for instance, is apparent at each level, but the eastern high pressure does not conform to that at sea level, and the small high-pressure region in Nebraska and South Dakota on the 16th does not even appear on the 1-kilometer map, being overrun by westerly or northwesterly winds.

CHARTS IV–V.

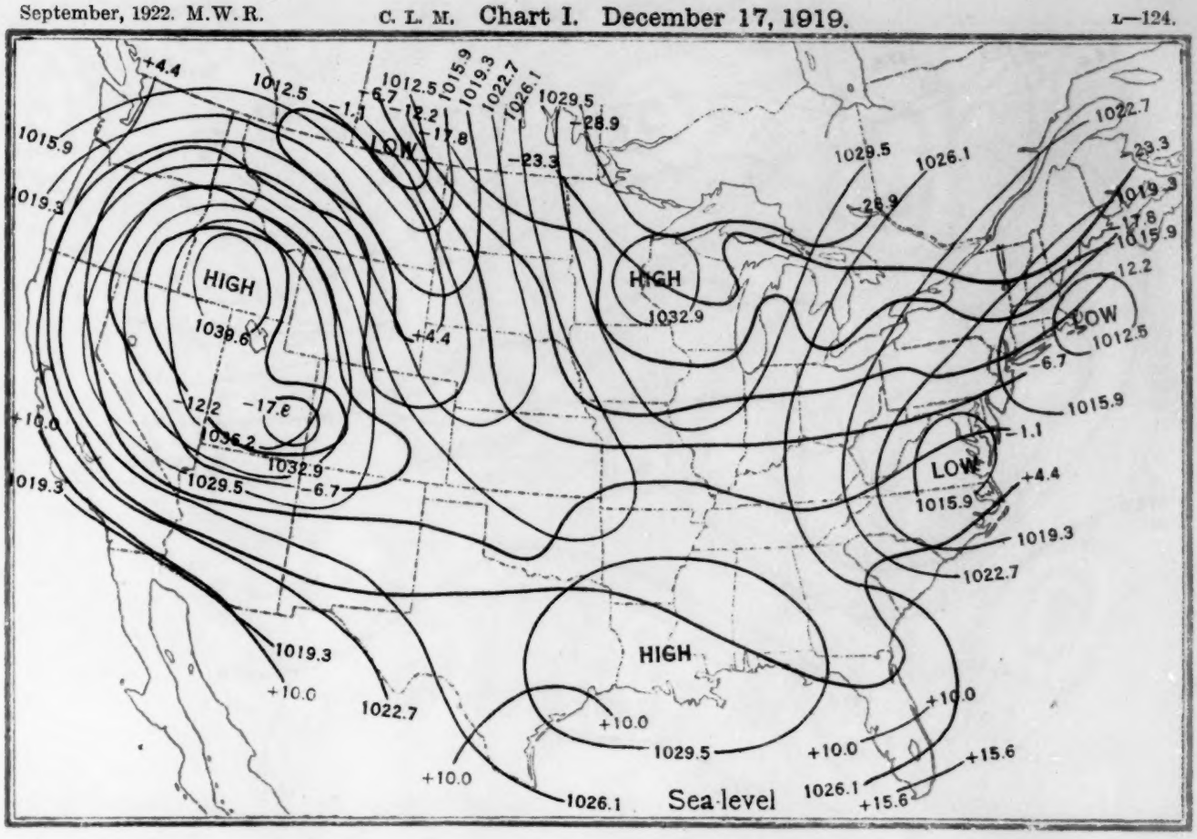
October 16–17, 1914.—In the original publication, this series of maps extends from October 11 to 18, 1914, but only two of these have been selected for reproduction here. Preceding the first of these two maps, on the 13th, there appeared on the sea-level map what might be described as a tongue of low pressure overspreading the country from the Gulf of Mexico. On that date this does not appear in the free-air maps. The only response to low-pressure activity in the Gulf region comes on the 15th, when the low center at 2 kilometers is found over southern Alabama, while another center of equal intensity is over Lake Superior. The following day there has occurred what appears as a merger of the two with a very much intensified center in west-central Illinois.

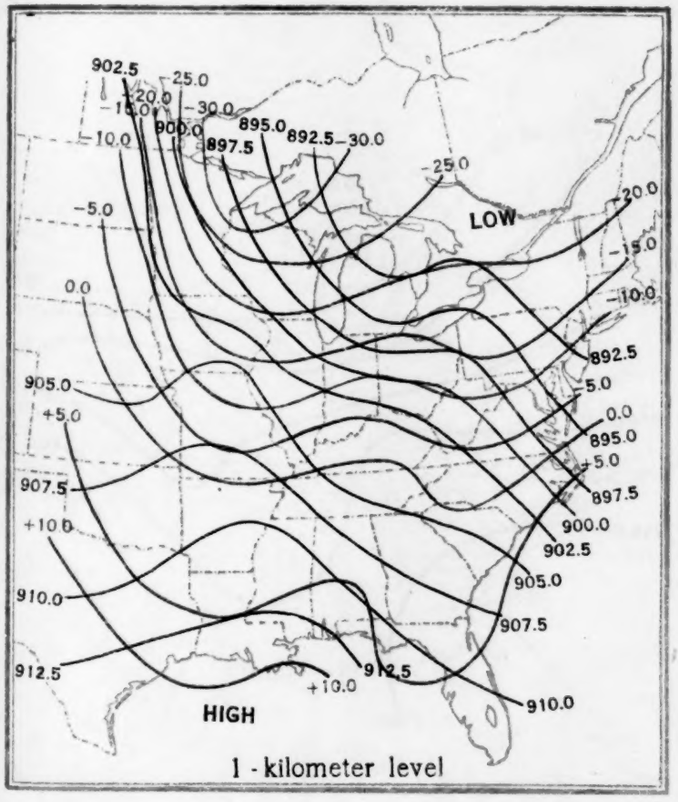
This disturbance is nearly circular, its importational power is most perfectly developed, and low temperature is found intruding from the west until the temperature of the south half of the formation is lower than that of the north half. This is significant with respect to rainfall. Here is cold dry air imported from the west and northwest; the warmer, moisture-laden air from the Gulf and South Atlantic coasts is drawn with pinwheel symmetry into the north half of the storm. This effect, apparent at both levels in the free air, but complicated at sea level by the tri-centered low area in the east, seems to explain the occurrence of precipitation in the north half of the storm and but little south of the free-air center.

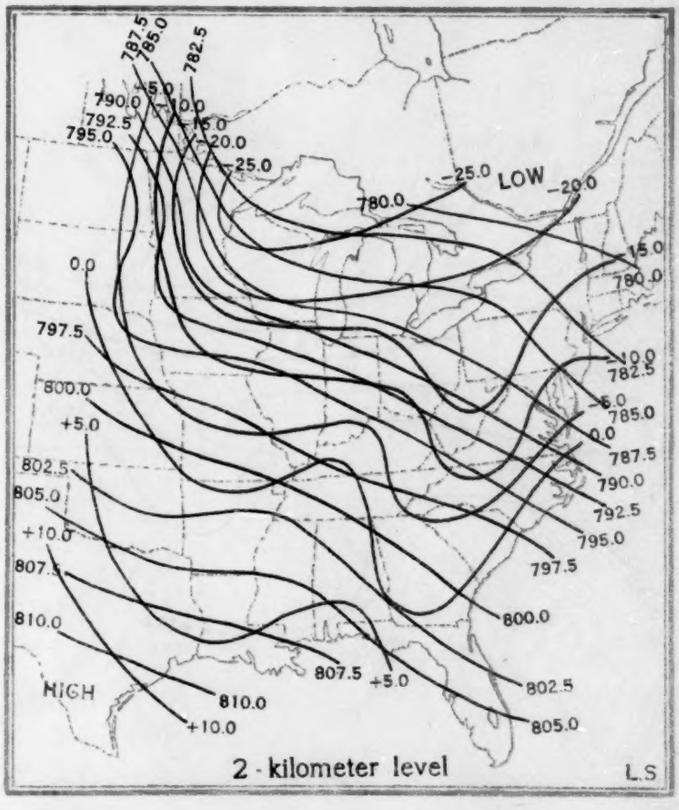
The shifting of the center to the west in the free air is also the result of the marked development of the temperature contrast between front and rear of the cyclone.

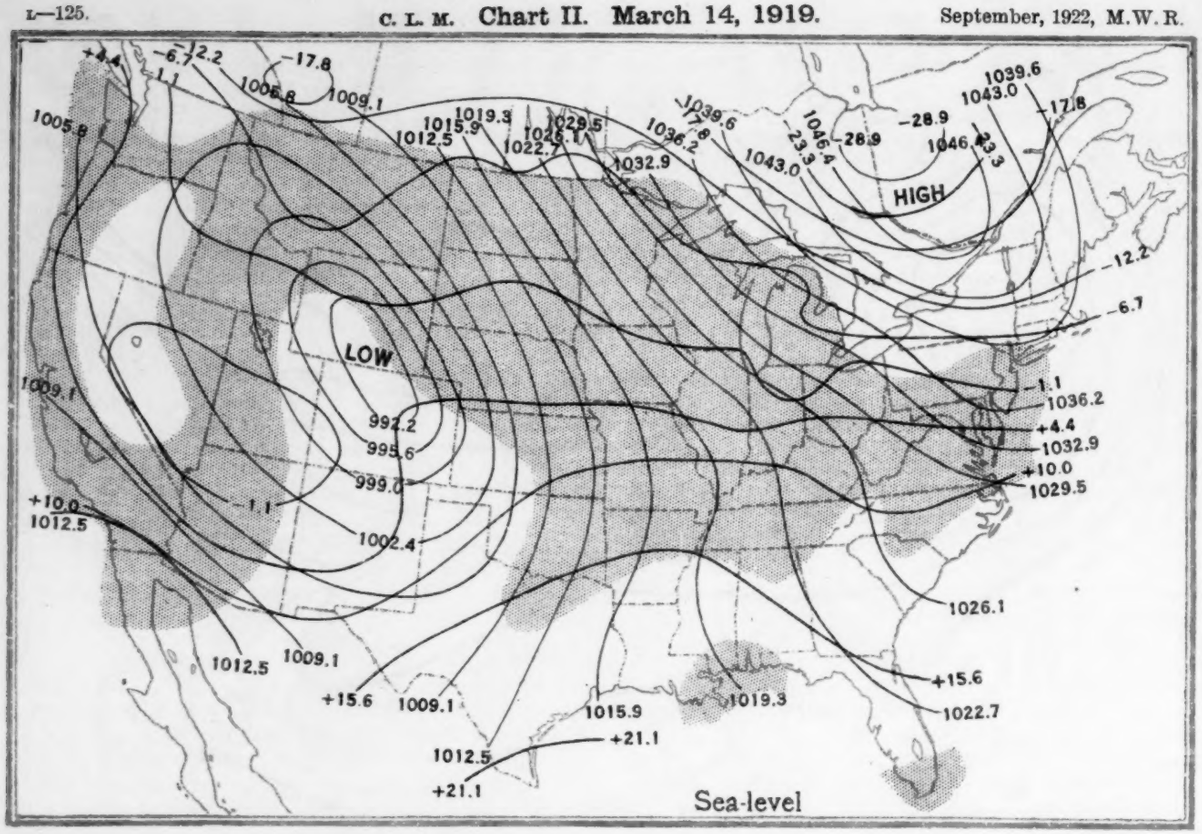
Having actually curled about itself streams of air of considerable temperature difference, it is found that on the 17th there is an isolated mass of cold air cast adrift in the southeast quadrant (1 kilometer) and a symmetrically located mass of warm air detached north of the previous storm center (2 kilometers). This latter warm air was certainly influential in splitting the low pressure in two at the 2-kilometer level. In general, this might lead to the suggestion that the anomalous temperature distribution is the cause of the rapid disintegration of what seemed on the 16th to be a well-developed circular cyclone in the free air. In other words, it is conceivable that the storm literally destroyed itself, at least in the lower layers, through its own vigor in mixing air currents of markedly differing temperature and humidity.[30] On the succeeding dates, the barometric situation changed rapidly, and a new régime was begun which would introduce a whole new series of charts.

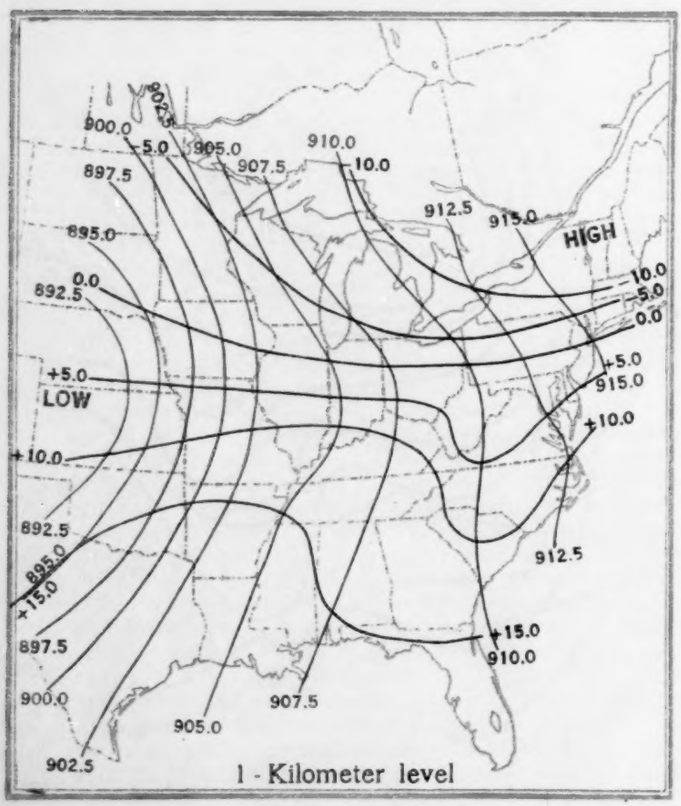
[30] Since sending the manuscript to press, a new paper by J. Bjerknes and H. Solberg entitled, "Life cycle of cyclones and the polar front theory of atmospheric circulation" *Geofysiske Publikationer*, Vol. III, No. 1, Kristiania, 1922) has appeared. In this paper it is shown how through the process of "occlusion," masses of warm air are cut off from the source and the dissolution of the cyclone follows.

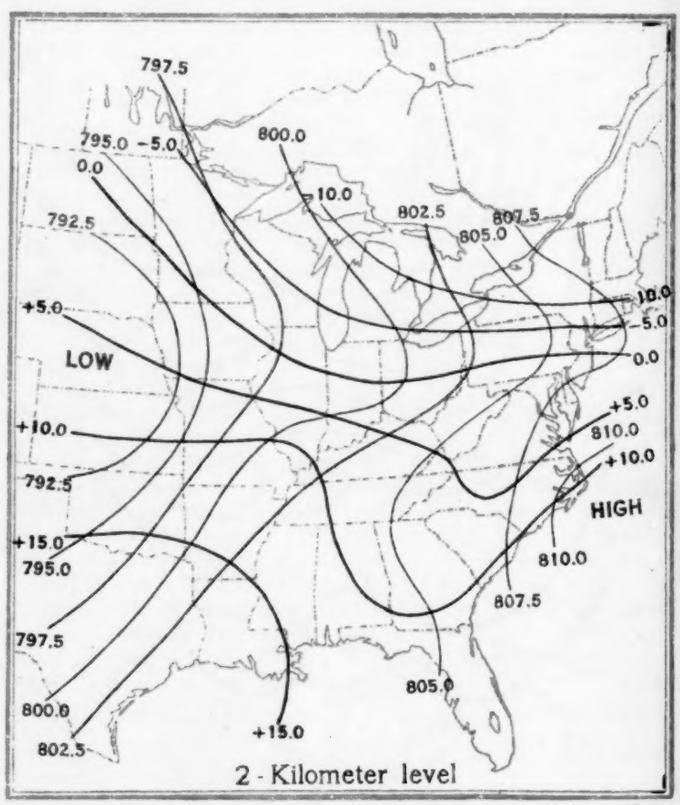

HIGH
1039.6
HIGH
1032.9
LOW
1012.5
LOW
1015.9
HIGH
1022.7
1029.5
1026.1
Sea-level

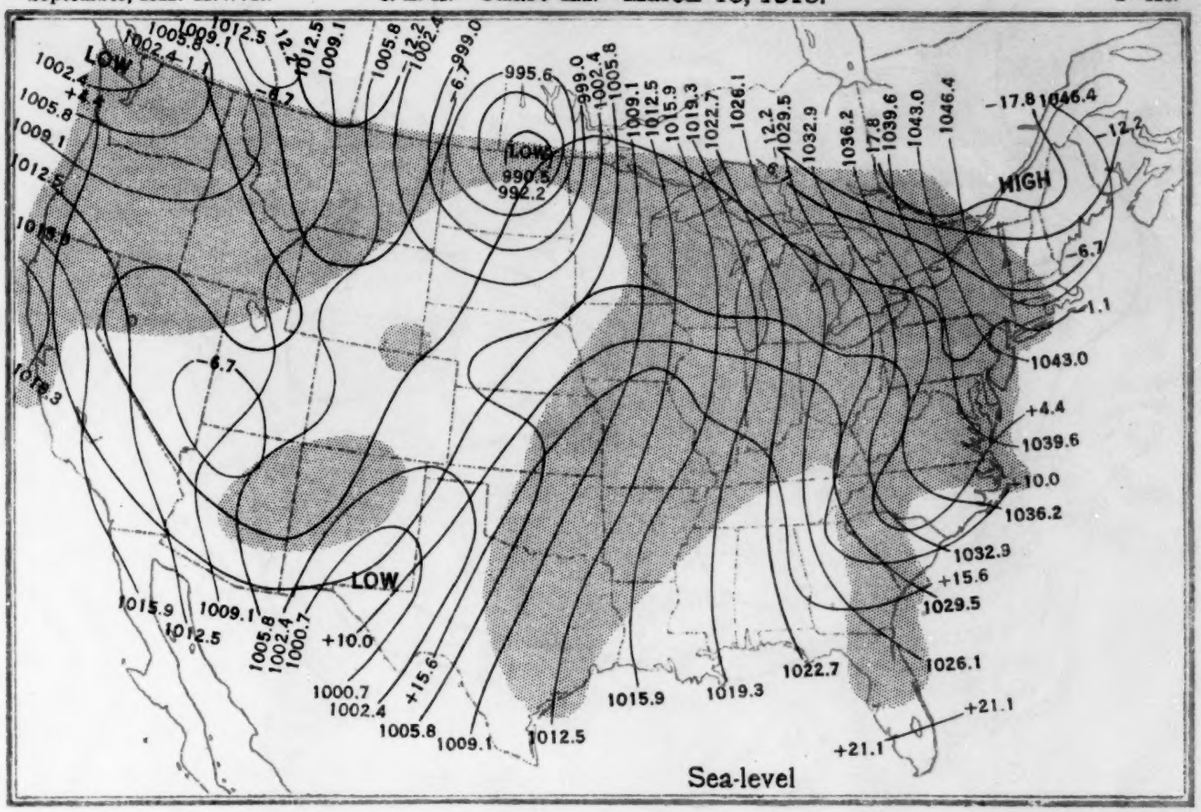

LOW
HIGH
1 - kilometer level

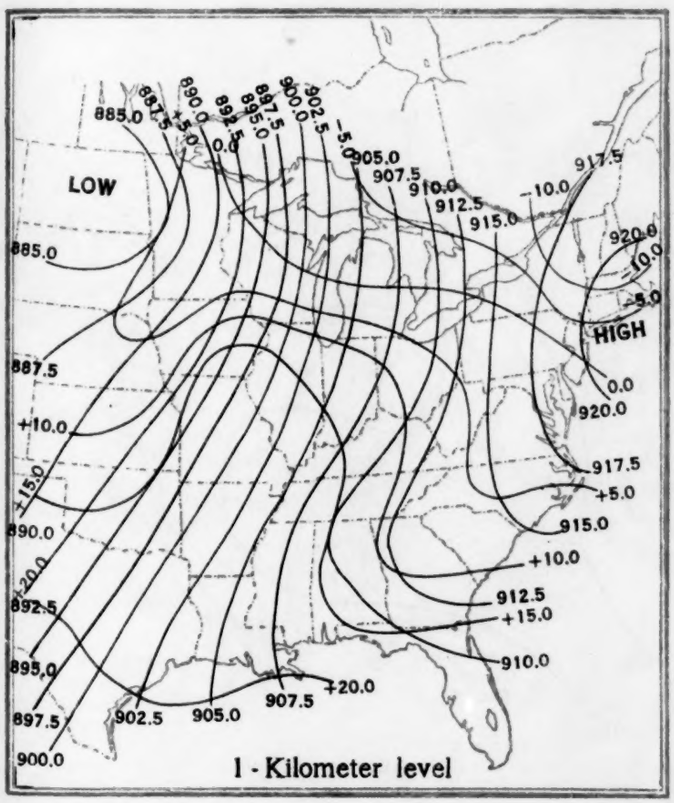

LOW
HIGH
2 - kilometer level
L.S

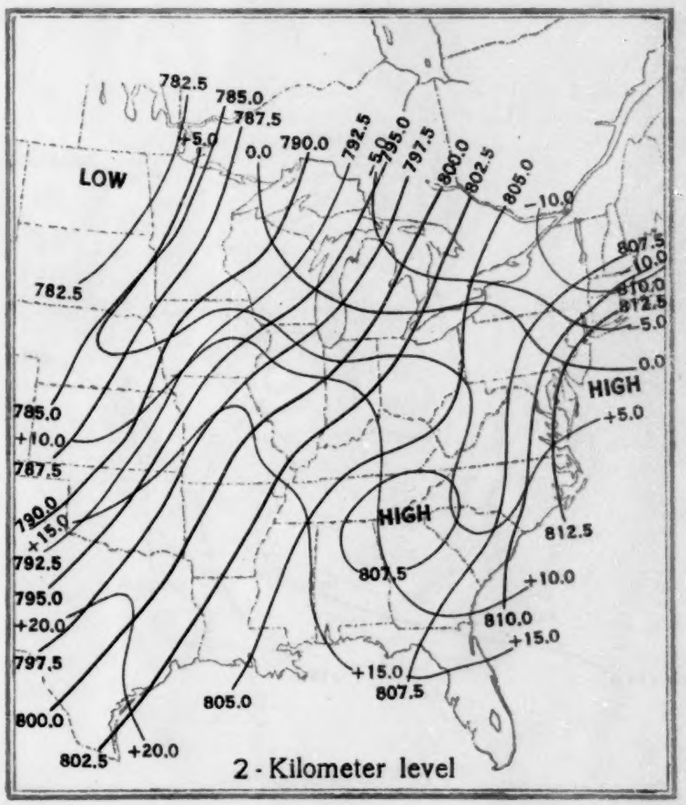

LOW
HIGH
1005.8
1009.1
1012.5
1015.9
1019.3
1022.7
1026.1
1029.5
1032.9
1036.2
1039.6
1043.0
1046.4
992.2
995.6
999.0
1002.4
+4.4
-6.7
-12.2
-17.8
1.1
-23.3
-28.9
+10.0
+15.6
+21.1
Sea-level

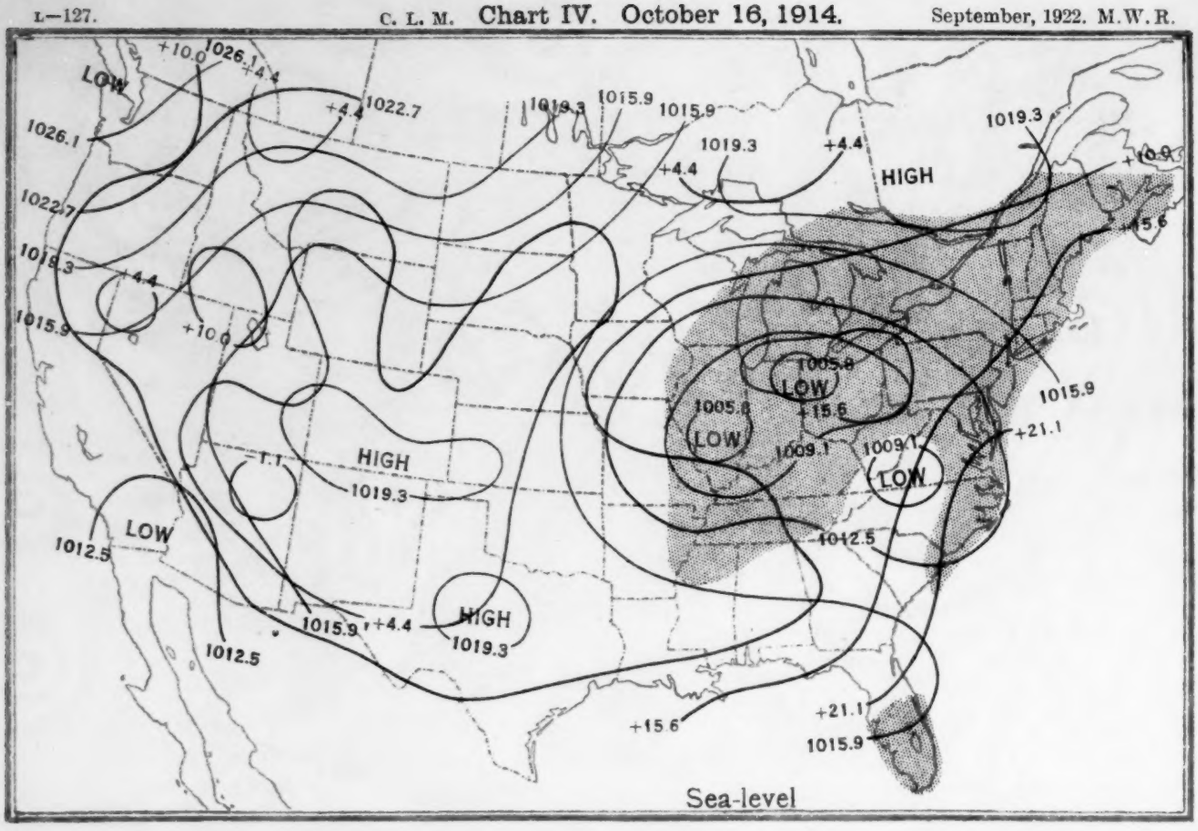

LOW
HIGH
900.0
905.0
910.0
915.0
892.5
895.0
897.5
902.5
907.5
912.5
0.0
+5.0
+10.0
+15.0
1 - Kilometer level

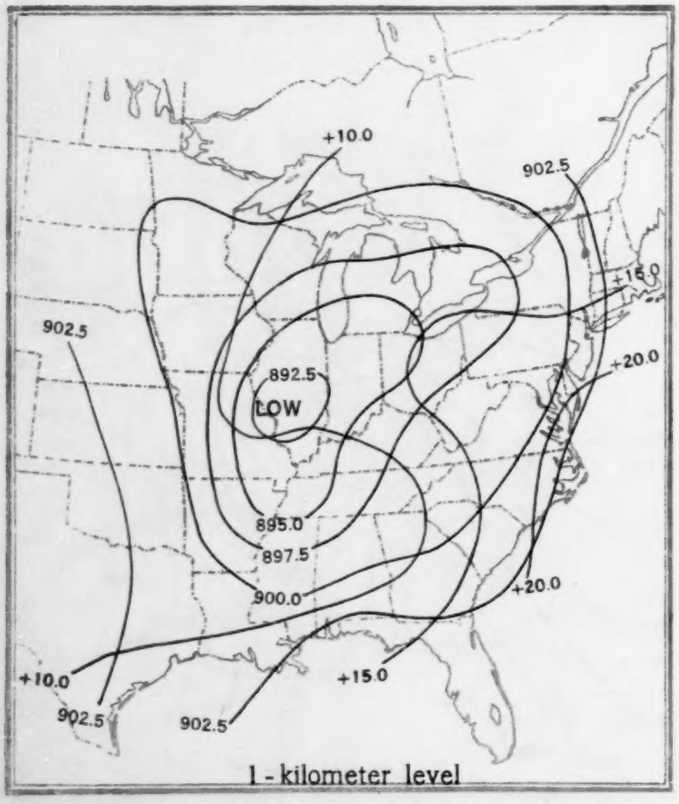

LOW
HIGH
792.5
795.0
797.5
800.0
802.5
805.0
807.5
810.0
0.0
-5.0
+5.0
+10.0
+15.0
2 - Kilometer level

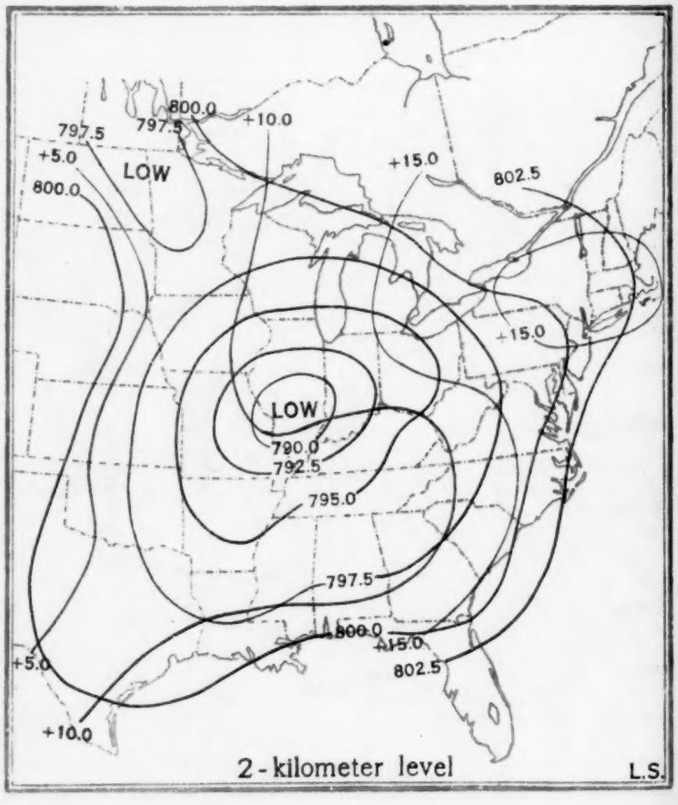

LOW
LOW
LOW
HIGH
Sea-level

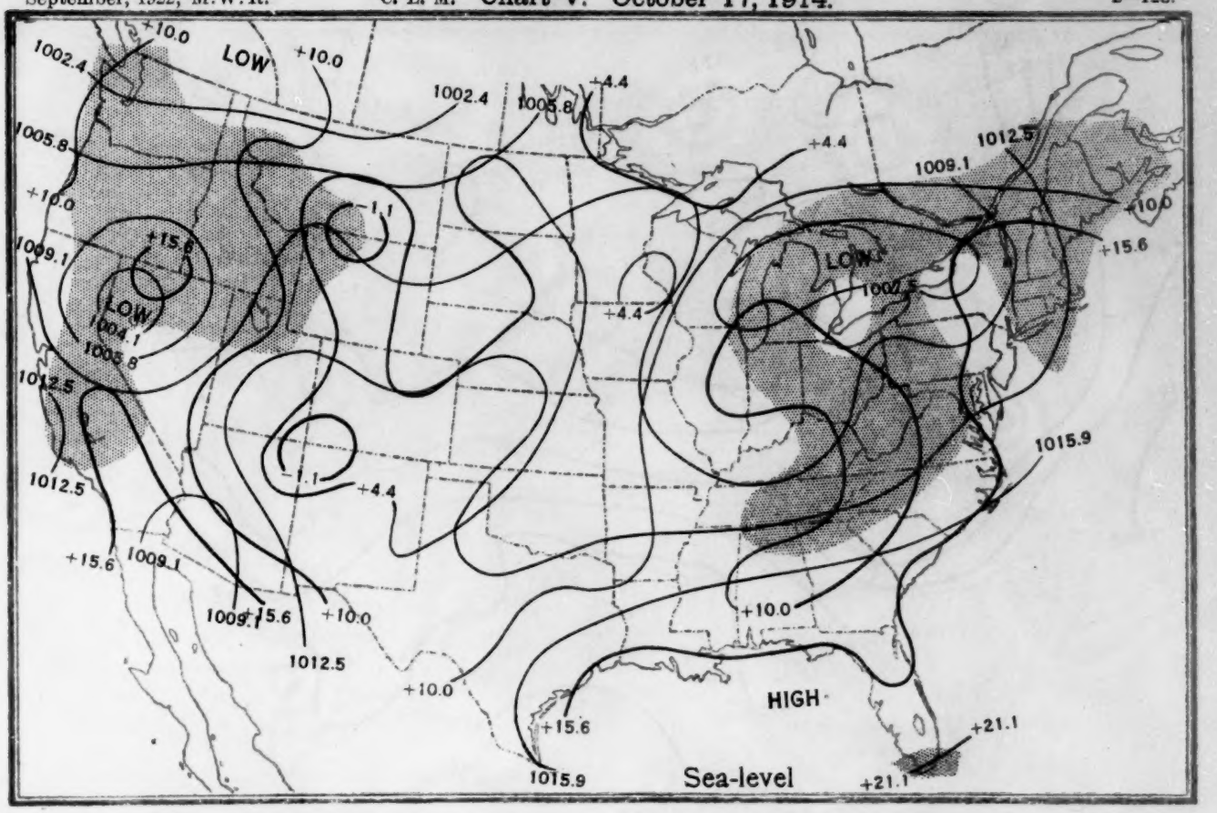

LOW
HIGH
1 - Kilometer level

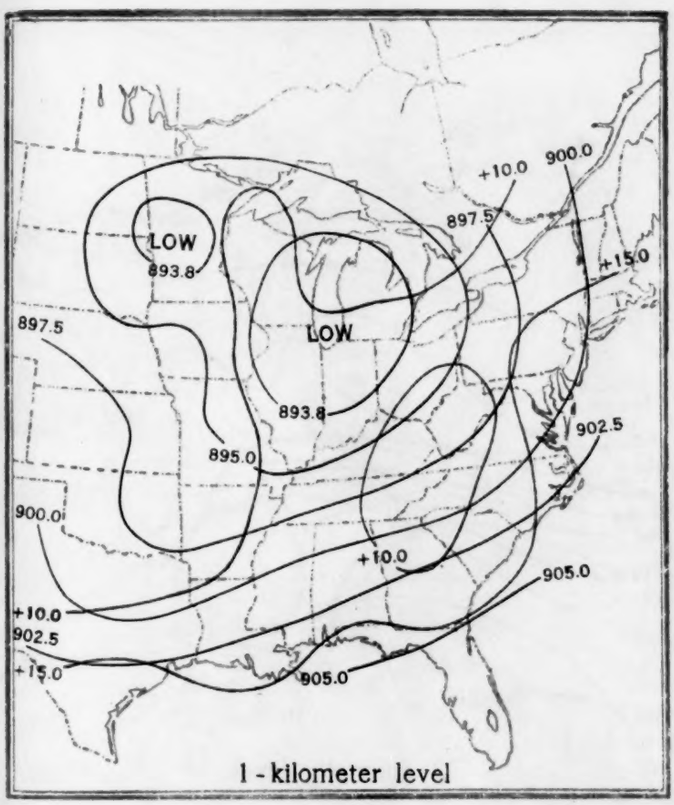

LOW
HIGH
HIGH
2 - Kilometer level

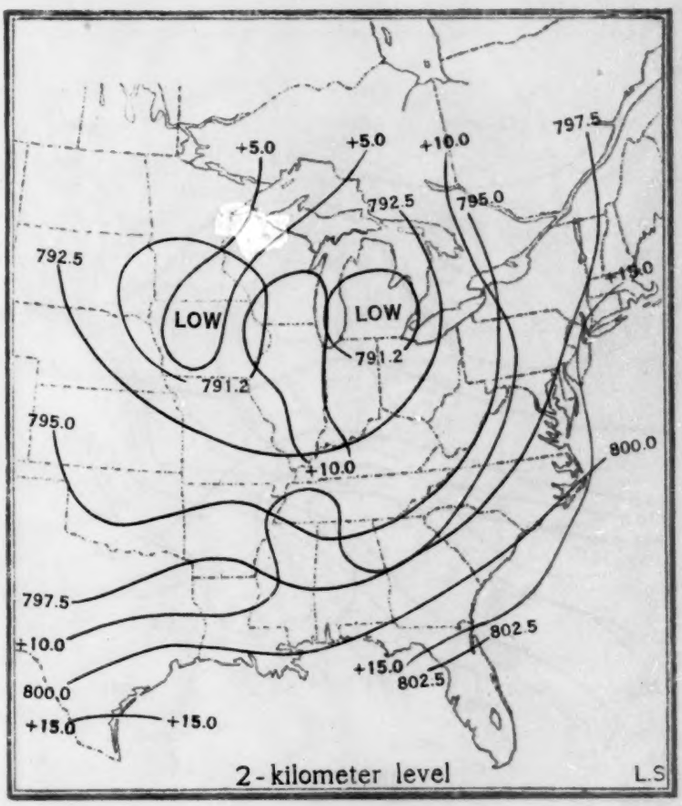

LOW
1026.1
+10.0
+4.4
1022.7
1019.3
1015.9
1019.3
+4.4
HIGH
+10.0
1005.8
LOW
+15.6
1009.1
+21.1
-1.1
HIGH
1019.3
LOW
1012.5
+4.4
HIGH
1019.3
+15.6
Sea-level

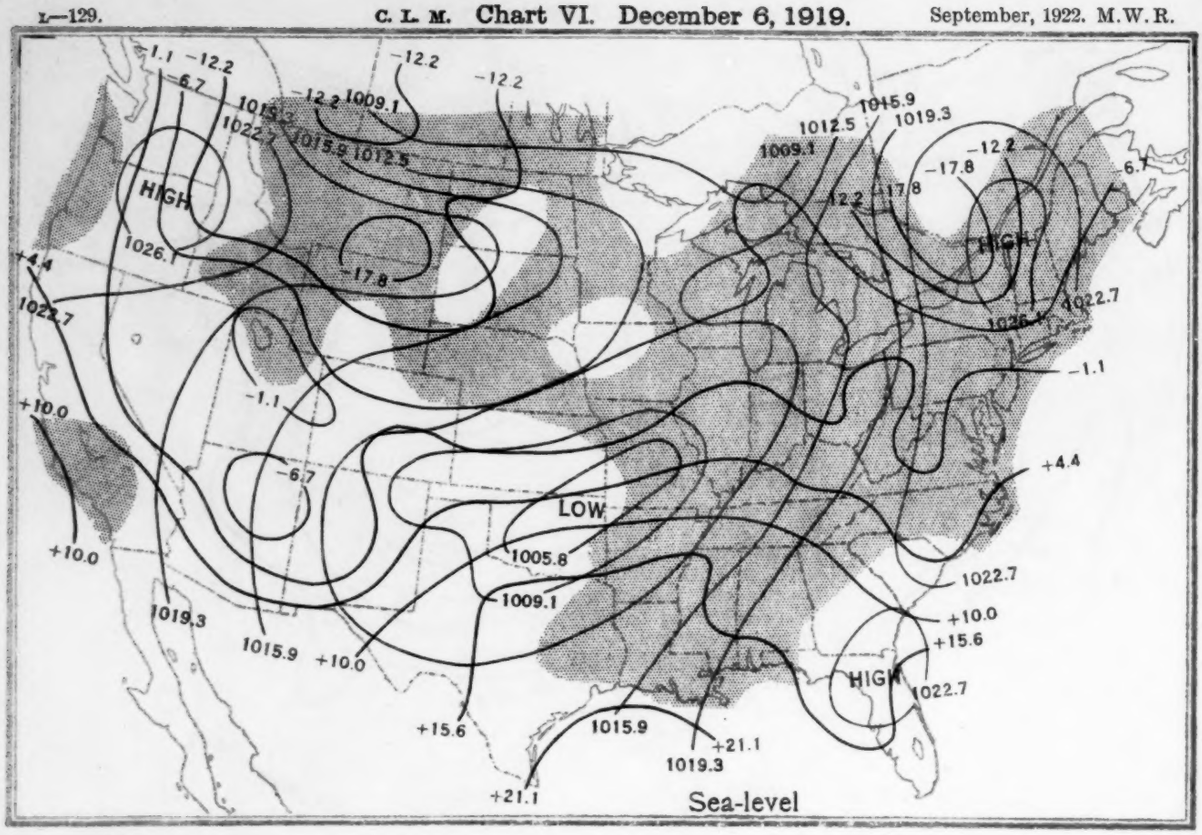

+10.0
902.5
+15.0
+20.0
892.5
LOW
895.0
897.5
900.0
1-kilometer level

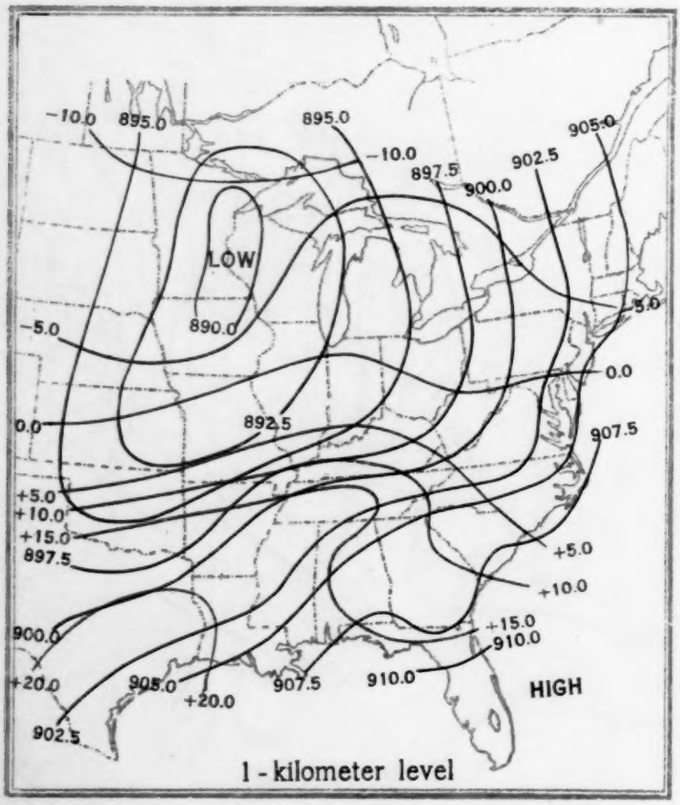

800.0
797.5
+10.0
+5.0
LOW
+15.0
802.5
790.0
792.5
795.0
797.5
2-kilometer level
L.S.

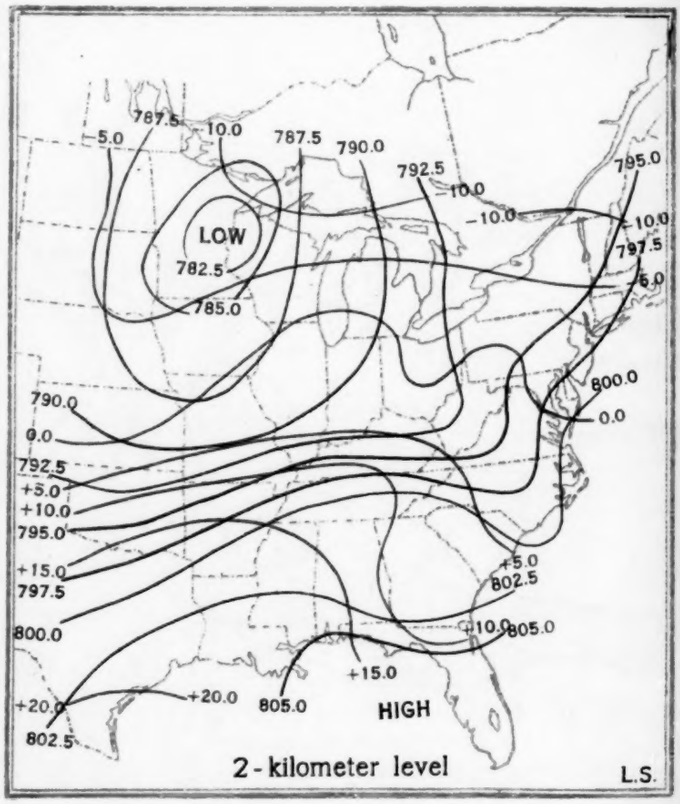

LOW
LOW
LOW
HIGH
1002.4
1005.8
1009.1
1012.5
1015.9
+10.0
+15.6
+4.4
-1.1
+21.1
Sea-level

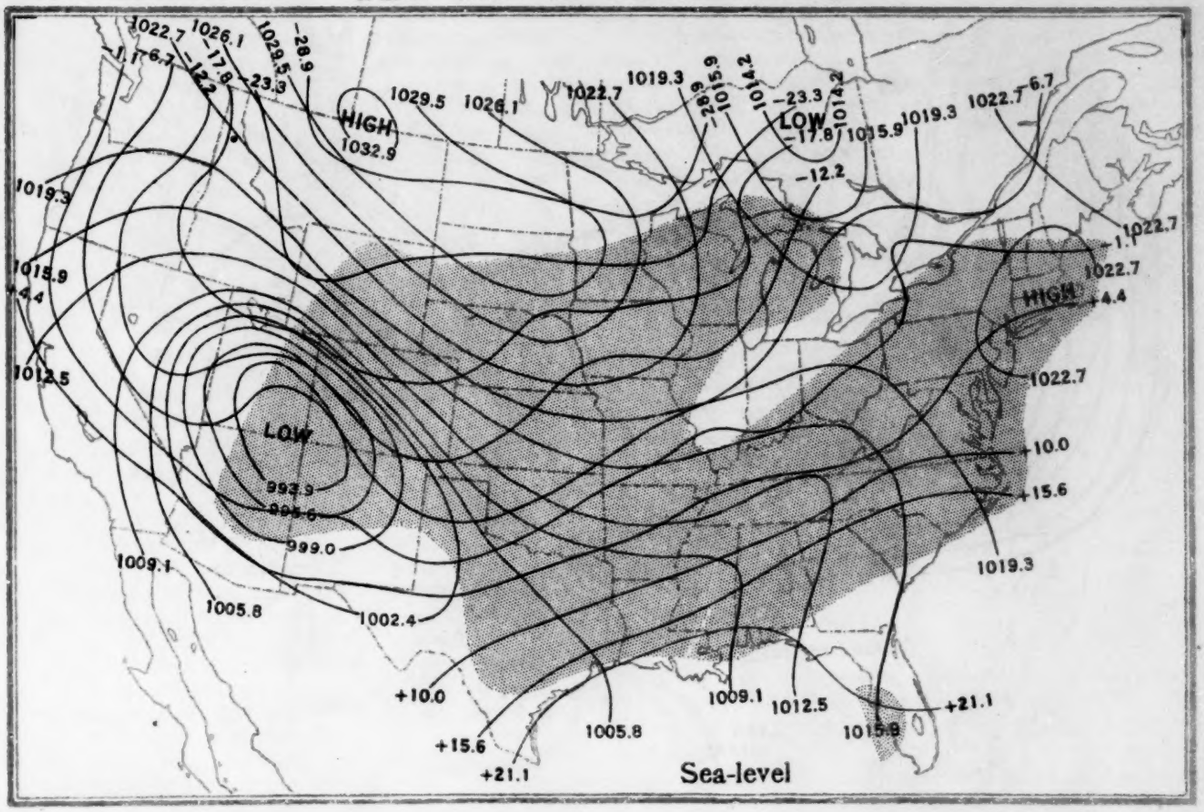

LOW
LOW
893.8
897.5
900.0
902.5
905.0
+10.0
+15.0
1-kilometer level

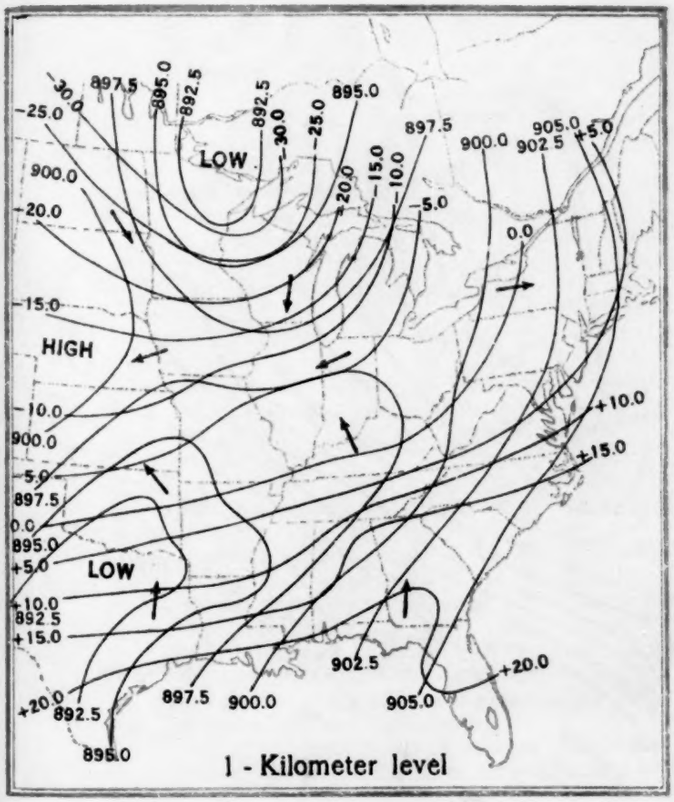

LOW
LOW
791.2
792.5
795.0
797.5
800.0
802.5
+5.0
+10.0
+15.0
2-kilometer level
L.S

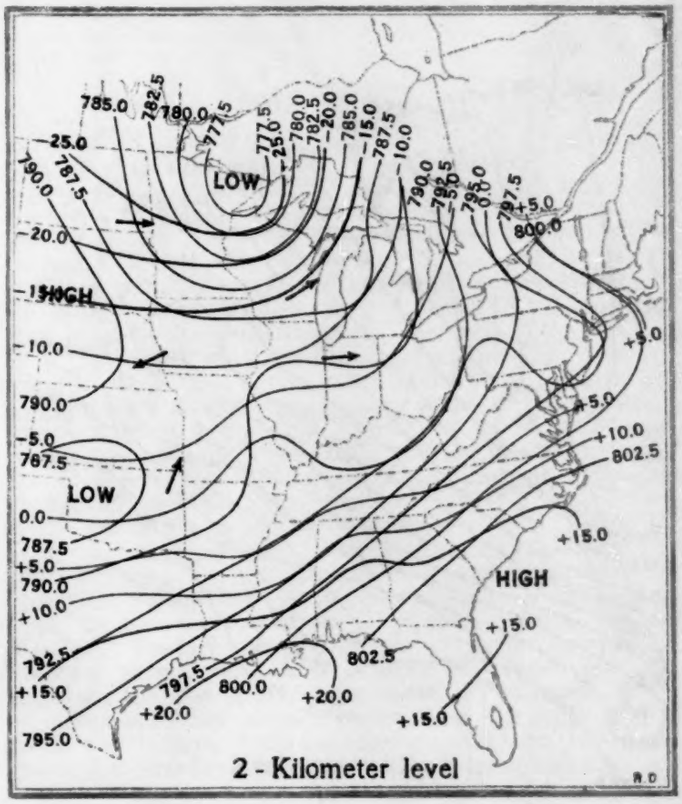

HIGH
LOW
HIGH
HIGH
Sea-level

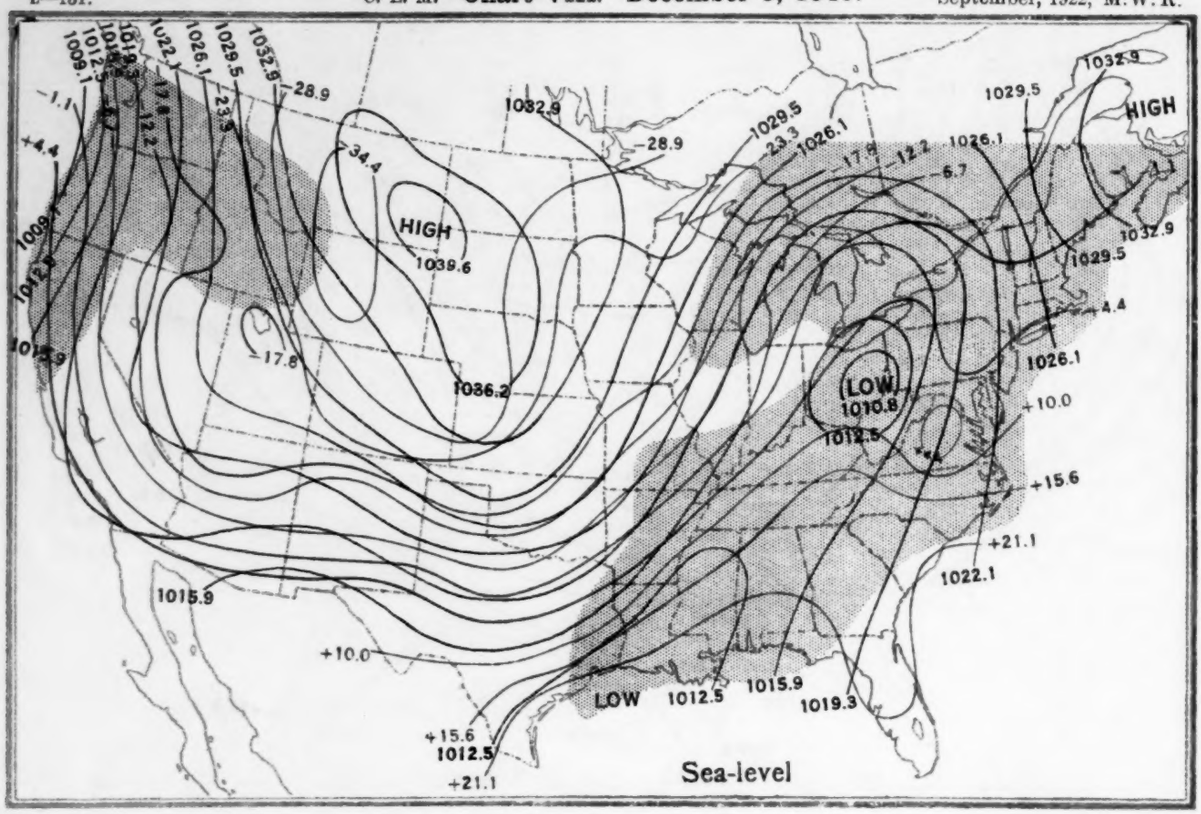

LOW
HIGH
1 - kilometer level

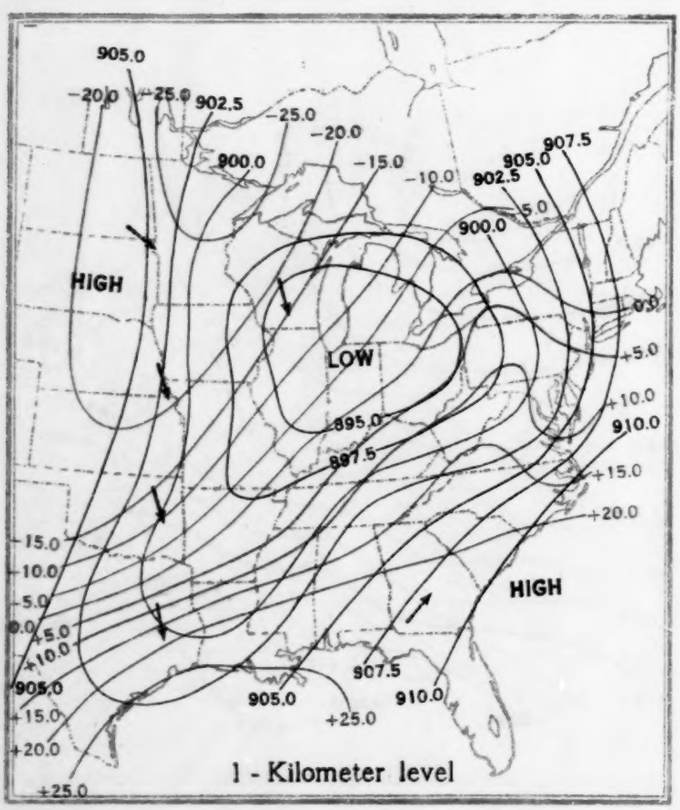

LOW
HIGH
2 - kilometer level
L.S.

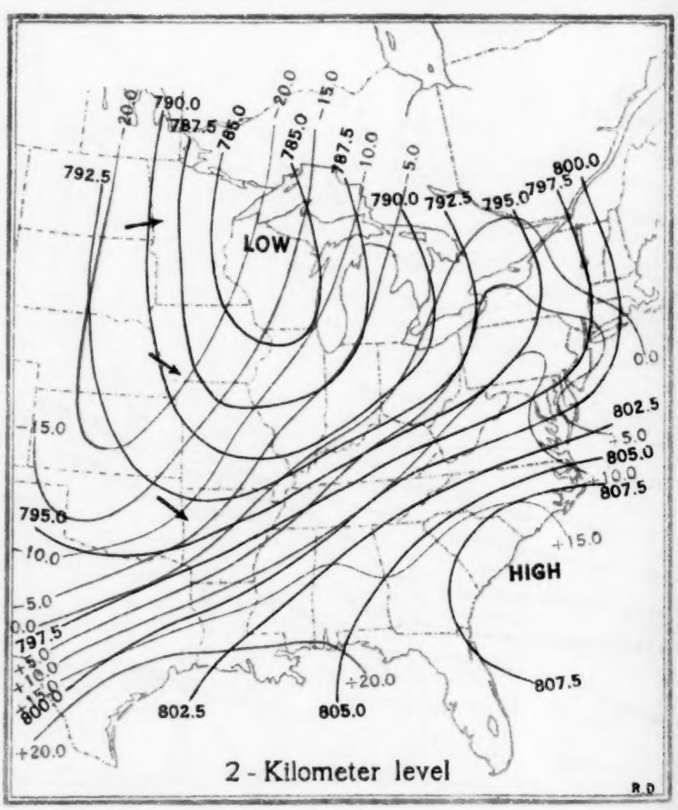

HIGH
LOW
Sea-level


LOW
HIGH
LOW
1 - Kilometer level


LOW
HIGH
LOW
HIGH
2 - Kilometer level


HIGH
LOW
1039.6
1036.2
1010.8
1012.5
1015.9
1019.3
1022.1
1032.9
1029.5
1026.1
Sea-level


HIGH
LOW
HIGH
1 - Kilometer level


LOW
HIGH
2 - Kilometer level

Attention is again invited to the importance of these maps in aviation. Here we have had a wide expanse of country largely cloud covered. Had aerological stations been functioning in 1914, they could have afforded little assistance in the matter of free-air movements. The circulation aloft was well defined, but it was not so apparent at the surface; the gradients aloft were quite steep and it is likely that high winds prevailed. Would these maps have aided the aviator?

CHARTS VI–VIII.

December 6, 8, and 9, 1919.—On the 5th and the following days the low-pressure center in the free air was north of the sea-level center; in fact, when the sea-level cyclone was centered in eastern Oklahoma the upper center was in Minnesota. Such shifting was undoubtedly the result of the low temperatures prevailing in the north. With the establishment of a strong southwesterly drift, the temperature contrast was accentuated so that the isobars followed the trend of the isotherms very closely.

The low center in the Lake region, being circular and slow moving, developed considerable intensity and introduced extremely cold air, farther and farther to the south in the Mississippi Valley, while the front was being fed with a steady stream from the southwest. The meeting place of these two drifts of differing temperature occurred along a band from northeast Texas to Indiana, where the surface temperature gradient gave a simultaneous temperature difference of 20° C., between the north and south ends of Illinois on the 9th.

The map for the 9th gives a splendid example of the shift of the low-pressure center toward the west and northwest when there is strong temperature contrast between front and rear. In this case the sea-level center is in West Virginia, the 1-kilometer center is in northern Indiana, and the 2-kilometer center is in west central Wisconsin. How significant, then, must be the effects of importation of air from different sources—air of different moisture content and temperature—about depressions having the same core, but with this core sloping at a considerable angle from the vertical. The regions of rainfall in this series, especially in those maps near the end of the period, show this significance strikingly. It is interesting to observe how closely the rainfall region agrees with the sweeping streams of southerly air drawn forward by the pressure disturbance.

For the benefit of those who are desirous of observations to substantiate the rather startling shifting of the low-pressure center revealed in this series, Table 4 is offered. Pilot-balloon observations were limited in altitude practically universally to 1 kilometer or less, but at several of the kite stations the altitudes attained were somewhat greater.

Summary.—This cursory study has indicated that the fundamental considerations regarding the interaction of surface temperature and sea-level (surface) pressure in influencing free-air pressure are justified. Meteorological phenomena, influenced, as they are, by a multiplicity of factors, are often difficult to study, and these maps are not exceptional. Nevertheless, it is believed that the results of the interplay of these factors are much more clearly discernible in the free air than at the surface, because they are not subjected to the modifying influences of surface friction and turbulence.

The evidence of the dissipation of an area of low pressure in the lowest levels as a result of its own activity in importing air of strongly contrasting temperature, seems highly suggestive. The displacing of free-air centers through strong temperature contrasts, the conduct of free-air secondaries and their influence on surface conditions, the relation of these effects to the distribution of precipitation, are all subjects rich in importance to general forecasting.

The importance to aviation interests has already been emphasized. The perusal of these charts shows clearly that a correct surmise of what the winds are doing aloft is often impossible from the sea-level chart. This knowledge is, however, absolutely essential to the safe and efficient conduct of aerial traffic.

TABLE 4.—*Free-air winds at aerological stations December 8–9, 1922.*

[Speed in meters per second.]

I. OBSERVATIONS WITH KITES.

Station.		Dec. 8.		Dec. 9.	
		1 km.	2 km.	1 km.	2 km.
Royal Center, Ind.	Direction..	ENE.	[1] W.	.....	.....
	Velocity...	.....	8.9	.....	.....
Ellendale, N. Dak.	Direction..	NW.	W.	WNW.	WSW.
	Velocity...	10.7	12.3	7.9	7.4
Drexel, Nebr.	Direction..	ENE.	[2] ENE.	NNW.	WNW.
	Velocity...	12.7	2.4	13.4	12.3
Broken Arrow, Okla.	Direction..	SE.	SSW.	NNW.	[3] WNW.
	Velocity...	12.5	16.7	16.2	17.6
Groesbeck, Tex.	Direction..	S.	.....	[4] NNW.	.....
	Velocity...	7.2	.....	17.3	.....

II. OBSERVATIONS WITH PILOT BALLOONS.

Ithaca, N. Y.	Direction..	W.	.....	.....	.....
	Velocity...	2	.....	.....	.....
Lansing, Mich.	Direction..	NNE.	.....	.....	.....
	Velocity...	1	.....	.....	.....
West Point, Ky.	Direction..	SSE.	.....	.....	.....
	Velocity...	13	.....	.....	.....
Madison, Wis.	Direction..	N.	SW.	NNW.	.....
	Velocity...	3	12	10	.....

[1] 1 p. m. observtion. [2] 1,815 meters. [3] 1,842 meters. [4] 658 meters.

CONCLUSION.

This study aims to carry the process of free-air reduction to the point where it can be performed at meteorological stations with a facility equal to that with which sea-level reductions are performed at present. The process is fully explained, the accuracy of the resulting maps is supported by much evidence, and a few specimen maps are drawn. The real test of the value of these maps can not be made by the author; that demonstration must rest with the forecaster, experienced, as he is, with daily weather controls, and sympathetic, as he must be, with the new charts, which will reveal to him pictures hitherto apparent only as fragmentary impressions. It is hoped that such a trial will lead to a more adequate conception of the processes at work in the lower levels of the atmosphere and a deeper appreciation of three-dimensional weather.

The method is both practicable and practical. There is no unsurmountable obstacle to the accomplishment of its objects and it can be turned at once into useful channels. It will assist in the most economical manner with the visualization of the third dimension of the weather. The labor of reduction can be performed with no more experience than is required for reduction to sea level, the basic material for the reduction embraces no observation not already required for the daily reports, and no more of the station observer's time will be required than is devoted at present to sea-level reduction.

The maps would give additional knowledge of the free-air winds. From the examples given in this paper it is obvious that many cases occur when the free-air conditions can not be accurately judged from sea-level data. These often occur at times of stormy weather when pilot-balloon observations are not available. Such times are likewise trying to the aviator, and it is then that he wants the most reliable advice.

It is believed that these maps will eventually have significance for general forecasting because of the close relation between free-air conditions and certain phases of surface weather, precipitation, cloudiness, and temperature. If these maps are found useful in the eastern United States and those tentative plans which have been suggested above for attacking the pleateau are found fruitful, there is the encouraging possibility that we may realize an ambition to blanket our country from coast to coast with a weather map of three dimensions. This may not be a universal panacea for all forecasting ills, but it will at least afford a glimpse of the physical processes at work, and lift us from the annoying disappointments of empiricism a little nearer to that ultimate goal toward which all students of weather forecasting are striving.

J. BJERKNES AND H. SOLBERG ON THE LIFE CYCLE OF CYCLONES AND THE POLAR FRONT THEORY OF ATMOSPHERIC CIRCULATION.[1]

By ALFRED J. HENRY.

[Weather Bureau, Washington, D. C., November 3, 1922.]

These two young Norwegian meteorologists have our best thanks for the clear presentation of their views on that perpetually interesting question of the origin and maintenance of cyclones and anticyclones. Readers of the REVIEW have had some intimation of the research work in forecasting that is being conducted at the Bergen Geophysical Institute from Miss Beck's paper in the August issue.[2] That article will serve as a prelude to the more formal presentation of the subject in the paper under review.

The elder Bjerknes, from a study of weather charts on which lines of flow were depicted and from other considerations, was led to a theory of the formation of cyclones and anticyclones, the germs of which, according to his own statement, are to be found in the writings of Dove and Helmholz. The latter in a paper on Atmospheric Motions[3] has shown that there is always a tendency toward the formation of a surface of discontinuity between air strata of different density which lie contiguous one above the other, and that at the bounding surfaces of such strata the conditions are ripe for the formation of atmospheric waves as soon as a lighter stratum lies above a denser one.

Professor Bjerknes has developed these ideas and applied them to the explanation of the origin and maintenance of cyclones and anticyclones. The air strata of different density most frequently met in nature are the two great currents, one flowing toward the Pole, the other toward the Equator. In a sense these are the counter currents of Bigelow and the opposing currents of Dove. How these currents act and react to form cyclones and anticyclones is perhaps best visualized from a drawing which the authors present under the title "Idealized cyclone." This diagram appeared in the August REVIEW, on page 404. They describe the principal features of the cyclone as consisting of two essentially different air masses, the one of cold, the other of warm origin. The two air masses are separated by a fairly distinct boundary surface which runs through the cyclone and which the authors believe may continue more or less distinctly through the greater part of the troposphere, being everywhere inclined toward the cold side at a small angle with the horizontal, say 1° or even 0.1°.

In the Northern Hemisphere the warm air is conveyed by a southwesterly or a westerly current on the southern side of the depression.[4]

At the front of this current the warm air ascends the wedge of colder air and gives rise to precipitation (warm front rain).[5]

The warm current is simultaneously attacked on its flank by cold air masses from the rear of the cyclone. Thereby part of the warm air is lifted and precipitation is formed (cold front rain).[6]

THE LIFE CYCLE OF CYCLONES.

The authors say that the more recent investigations have shown that the type of cyclone above described represents a certain stage of development in the life of a cyclone. The successive changes in form and structure are schematically shown in Figure 1, in which type *c* or *d* corresponds to the "ideal" cyclone mentioned above.

In the earlier stages the same cyclone has the structure shown in *a* and *b* and it will successively pass through the forms *e*, *f*, *g*, and *h* of Figure 1. As may be seen by that figure, the initial stage of formation is pictured in *a* wherein two oppositely directed currents a cold easterly (from the east) adjacent to and on the same level with a warm westerly (from the west) is separated by a nearly straight boundary.

At the place where the new cyclone is to be formed this originally straight boundary bulges out toward the cold side as in *b*, and the center of the cyclone will be found at the top of the projecting tongue of warm air. The tongue of warm air is identical with the warm sector of the cyclone, and the ascending air from this warm tongue forms the "warm front" rain and the "cold front" rain shown in *c* and *d*, respectively. This newly formed cyclone follows the current of warm air eastward and is propagated as a wave on the boundary surface between warm and cold air.

During the eastward motion, the amplitude of the warm wave increases (in a horizontal N-S direction as in

[1] *Geofisiske Publikationer*, Vol. III, No. 1: Kristiania, 1922.
[2] Pages 393–400.
[3] The mechanics of the earth's atmosphere. A collection of translations by C. Abbe, *Smithsonian Collections No. 843*.

[4] For the eastern part of the United States I should say that this specification should be modified to read the warm current is conveyed by a southwesterly to a southeasterly current on the southern or eastern side of the depression.—EDITOR.
[5] This is, of course, a very generalized statement to which there are many exceptions, so far as precipitation is concerned. In the case of a shift of the wind from offshore to onshore, when the land surface is quite cold precipitation occurs regardless of the position of the cyclone center, particularly along the Middle Atlantic coast.—EDITOR.
[6] In the United States cold front precipitation is not strongly marked in winter except as snow flurries in mountain districts and on the lee shores of the Great Lakes; in summer, however, the precipitation of a cyclone may be confined to cold front rain, which in many cases is clearly associated with the "wind shift" line in the rear.—EDITOR.

Figure 1*c*). Cold air curves around the northern end of the warm air and arrives in the rear of the cyclone as a northwesterly wind. This type corresponds to the previously described "ideal" cyclone. Simultaneously with the further increase in amplitude (Fig. 1*d*) the tongue of warm air narrows laterally, especially in the southern part of the cyclone. Finally as in Figure 1*e* cold air from the rear joins the cold air in front and thus cuts off the supply of warm air. In this phase the cyclone is said to be "secluded." The remaining part of the warm sector, near the center, also soon disappears so that the cyclone on the ground consists of cold air only. (Fig. 1.) For this type the authors have chosen the term "occluded" cyclone. At the place where the warm sector disappeared, a boundary line persists for some time between the cold air from the rear and the front of the cyclone, respectively. Finally, this boundary also disappears, Figure 1*g*, and the cyclone becomes a nearly symmetrical vortex of cold air. The large zones of continuous rain have then disappeared and precipitation occurs only as intermittent showers. These conditions then persist until the cyclone is wasted away.

During the first phase of the development of the cyclone —from its origin to the moment of occlusion—the warm air is lifted by the two wedges of cold air as they gradually approach each other. This process transforms part of the potential energy of the initial system into kinetic energy and from this fact the authors predicate the following rule: *All cyclones which are not yet occluded have increasing kinetic energy.* This is exemplified on the weather maps by an increase of wind force and usually a deepening of the depression. When a cyclone is found to be of the type shown by Figure 1 *a*, *b*, *c*, or *d* it may be forecast with great confidence that it will deepen.

After the two wedges of cold air have met on the ground the still existing upper warm sector will be further lifted by the cold air until it is cooled adiabatically to the temperature of air at the same level into which it ascends. As long as this stage has not been reached, kinetic energy will be gained by the process. Later, when the cyclone has become a homogeneous air vortex, it has no store of potential energy, and the existing motion can only be maintained by the inertia of the moving air-masses.

From the moment of occlusion—that is, when the cold air on the ground in the front and rear of the cyclone join—portions of the cold air must also begin to rise. This ascending motion is, however, not directly due to gravity. The adiabatic cooling will soon make the ascending column of cold air colder than its surroundings on the same level, so that the force of gravity will counteract the ascending motion of the cyclone. The kinetic energy of the cyclone from that movement is used to pump the cold air upward against gravity, a process by which the system loses kinetic energy. Thus in the interval of time just after occlusion kinetic energy is gained in the higher layers and lost in the lower. The first process, however, will stop just as soon as the upper warm sector reaches the layers having its own potential temperature, and the effect of the second process will finally alone determine the transformation of energy in the cyclone. Friction of air-masses favors the second process, so that the influences which cause kinetic energy to be transformed will soon preponderate after the occlusion takes place.

Therefore, the following precept: *After the occlusion the cyclone soon begins to fill up.*

The authors specifically state that their considerations of the problem have been upon the supposition that the warm and the cold air masses are separated by sharply defined boundaries or real surfaces of discontinuity—an ideal condition that is never perfectly fulfilled—and, further, that no thermal boundary surface forms between the two wedges of cold air meeting each other at the occlusion of the cyclone. They are of opinion that so far as the mechanism of the cyclone is concerned it makes no great difference whether, instead of a real surface of discontinuity, there exists merely a less accentuated boundary surface; nevertheless, *the essential condition for the formation of a cyclone is the coexistence of cold air and warm air masses adjacent to each other.*

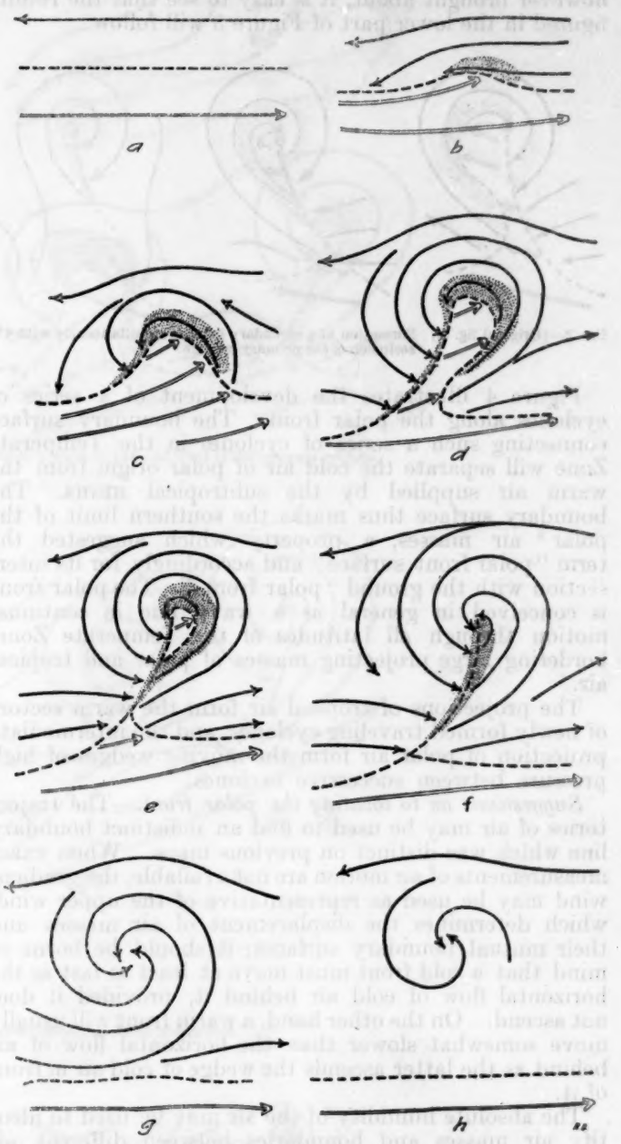


FIG. 1.—[Original fig. 2.] The "life cycle" of cyclones.

POLAR FRONT.

New cyclones usually form on thermal boundary surfaces which run through an existing primary[7] cyclone.

[7] The reviewer has taken the liberty of substituting "primary" for "mother" when the latter appears in the text.

The formation may take place according to either of the two schemes graphically presented in Figures 2 and 3. The most common type is that shown in Figure 3. In that illustration the cold front boundary surface, the dashed line, has a northward inflection some distance in the rear of the primary cyclone; a situation similar to that illustrated in Figure 1*b*. With this initial impulse, however brought about, it is easy to see that the results figured in the lower part of Figure 3 will follow.

FIG. 2.—[Original fig. 6.] Formation of a secondary cyclone simultaneously with the seclusion of the primary cyclone.

Figure 4 illustrates the development of a series of cyclones along the polar front. The boundary surface connecting such a series of cyclones in the Temperate Zone will separate the cold air of polar origin from the warm air supplied by the subtropical HIGHS. The boundary surface thus marks the southern limit of the polar [8] air masses, a property which suggested the term "polar front surface" and accordingly for its intersection with the ground "polar front." The polar front is conceived in general as a wavy line in continual motion through all latitudes of the Temperate Zone, bordering large projecting masses of polar and tropical air.

The projections of tropical air form the warm sectors of newly formed traveling cyclones, and the intermediate projection of polar air form the moving wedges of high pressure between successive cyclones.

Suggestions as to locating the polar front.—The trajectories of air may be used to find an indistinct boundary line which was distinct on previous maps. When exact measurements of air motion are not available, the gradient wind may be used as representative of the upper wind, which determines the displacement of air masses and their mutual boundary surfaces; it should be borne in mind that a cold front must move at least as fast as the horizontal flow of cold air behind it, provided it does not ascend. On the other hand, a warm front will usually move somewhat slower than the horizontal flow of air behind as the latter ascends the wedge of cold air in front of it.

The absolute humidity of the air may be used to identify air masses and boundaries between different air masses in cases when insolation or radiation have effaced the thermal discontinuity. At stations on the sea coast the differences between the air temperature over the sea and over the land, respectively, may be used to determine the origin of the air.

Temperature in the free air from kites or aeroplanes are also useful in the analysis of the polar front.

[8] The reviewer interprets the expression "polar" air to mean any mass of air which for the time being is colder than its surroundings, regardless of its apparent origin. On weather charts which do not include the higher latitudes it is not always possible to determine the origin of the air streams portrayed on the map.

THE CYCLONE FAMILIES.

In a series of cyclones formed on one and the same polar front, each cyclone usually follows a track lying south of that of the preceding cyclone. After a certain number of such cyclones the polar front reaches the region of the subtropical HIGHS, whence a steady transport of air takes place through the trade winds toward the Equator. In some conspicuous cases the arrival of polar air may be observed as a sudden but slight decrease of the temperature of the trade wind, but usually the polar air soon amalgamates with the adjacent tropical air. The polar air thus entering the trades leaves the cyclonic circulation of the Temperate Zone for a considerable length of time and will be transferred into real tropical air during its stay in equatorial regions. The authors next lay down the following precept: *When the polar air from the rear of one cyclone enters the trade winds the next cyclone will usually appear on a more northern track* and follow a new polar front, which is not directly connected with the previous one.

On this new polar front the same phenomenon will be reproduced as on the old polar front. The cyclones will follow, step by step, more southern tracks until the polar air again reaches the Tropics and the same cycle of events is repeated.

This periodicity enables us to divide cyclones into groups which have been called cyclone families.[9]

Each family begins with the first cyclone traveling along a track north of that of the preceding cyclone and ends with the cyclone traveling so far south that it brings the polar air down into the trade-wind system. All cyclones of one family are thus formed on one and the same polar front. Moreover, each new family is formed on another polar front not connected with either the polar front of the foregoing or of the following cyclone families. When such a cyclone family passes usually four individual cyclones are observed from a fixed place, centrally within the cyclone belt. This number may, however, vary considerably from one family to another.

The single members of a cyclone family are usually of different ages. In Europe the first and second cyclones of any family, which for convenience may be called the A and B cyclones are mostly of the vanishing type when they arrive from the Atlantic. The later members, the C and D cyclones are, however, mostly of less age and show increasing intensity during their passage over Europe.

From these facts the conclusion is reached that the A and B cyclones are formed relatively far west of Europe and have traveled for several days before arriving at the western coast of that Continent, whereas the C and D cyclones are formed nearer to Europe. Accordingly we may expect the A cyclone to vanish within the region embraced by the Norwegian weather map, while the B cyclone will pass farther to the eastward and the C and D cyclones still farther before they disappear.

When the A cyclone vanishes the B cyclone becomes the foremost member of the family, when the B cyclone vanishes the C cyclone becomes the foremost member and so on.

Although the single cyclone usually persists only about a week, the cyclone family may theoretically live indefinitely, since it is being renewed by the creation of new cyclones behind the vanishing ones.

[9] Cf. MO. WEATHER REV. 50: 16-20.

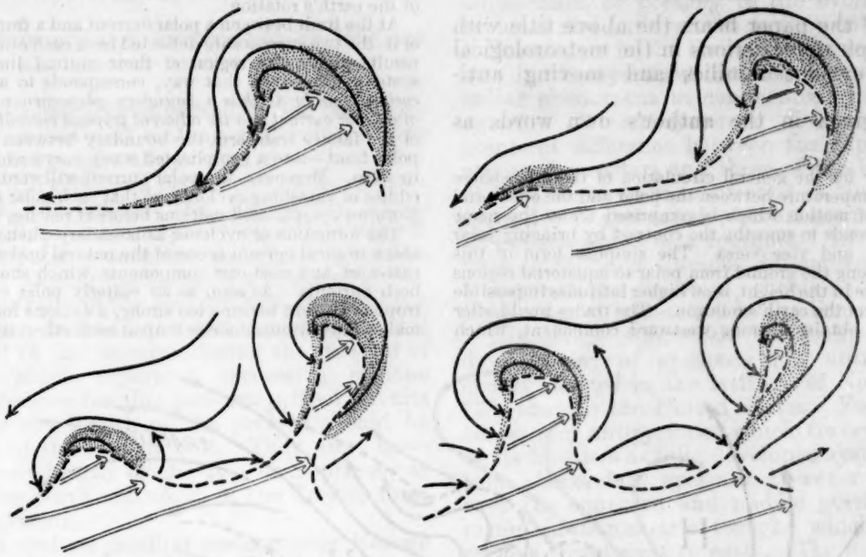


FIG. 3.—[Original fig. 8.] Formation of a secondary cyclone as a wave on the cold front of the primary cyclone.

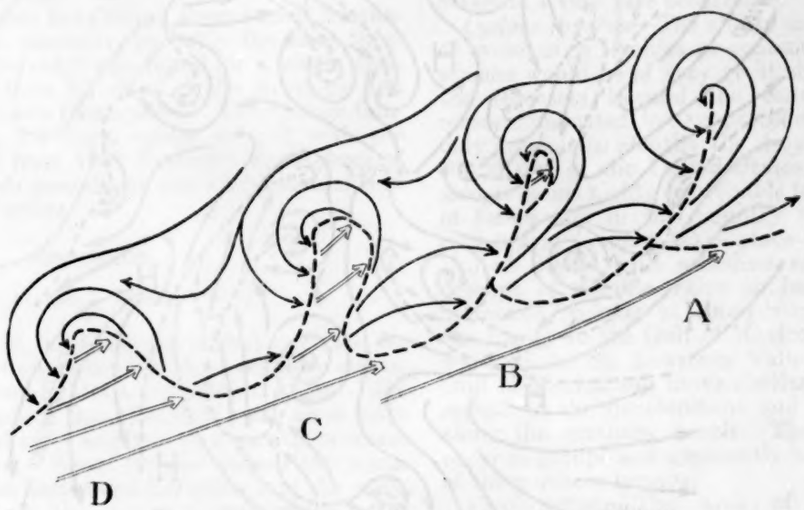


FIG. 4.—[Original fig. 9.] The polar front through a series of cyclones.

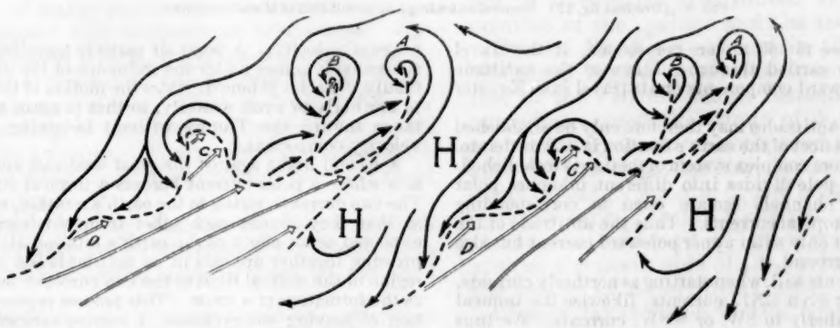


FIG. 5.—[Original fig. 10.] Cyclone families.

THE POLAR-FRONT THEORY OF THE GENERAL ATMOSPHERIC CIRCULATION.[10]

The final part of the paper bears the above title with a separate paragraph upon periods in the meteorological elements due to cyclone families and moving anticyclones.

The theory is given in the author's own words as follows:

The source of energy for the general circulation of the atmosphere lies in the contrast of temperature between the polar and the equatorial regions. The system of motion which is comprised under the name "General circulation" tends to smoothe the contrast by bringing polar air to tropical regions, and vice versa. The simplest form of this system, a trade wind along the ground from polar to equatorial regions and a returning antitrade in the height, is on higher latitudes impossible on account of the effect of the earth's rotation. The trades would after some travel southward obtain a strong westward component, which would theoretically increase to 460 meters per second, if the travel to the Equator should be carried through. Likewise the antitrade would reach enormous eastward components on its travel from Equator to the pole.

The system of trades and antitrades may therefore only be established in low latitudes, where the effect of the earth's rotation is still moderate. In the Temperate Zone a more complex system of motion is established. The trade wind from the pole divides into different branches polar currents between which channels remain open to corresponding branches of the antitrade-tropical currents. Thus the antitrade of the Temperate Zone appears not only as an upper poleward current but also as tropical currents on the ground.

The particular polar currents will, when starting as northerly currents, tend to deviate into NE. or even ENE. currents; likewise the tropical currents deviate from southerly to SW. or WSW. currents. We thus have a system of alternate polar and tropical currents beside each other, winding up spirally round the earth's axis.

These currents will hinder each other from obtaining the great west-east or east-west components which were to be expected from the effect of the earth's rotation.

At the limit between a polar current and a tropical current to the east of it, the two currents are deflected from each other, so that an air deficit results above the region of their mutual limit. The low-pressure system, formed in that way, corresponds to a cyclone family. *The cyclone family is thus a boundary phenomenon between the left flank of a polar current and the adjacent tropical current.* The single cyclones of the family transform the boundary between the two currents—the polar front—into a complicated wavy curve which constantly changes its form. Moreover, the polar current will contain within itself all the eddies of vanishing cyclones, so that each polar air particle of necessity performs complicated motions before it reaches the Tropics.

The formation of cyclones as boundary phenomena between a polar and a tropical current is one of the natural brakes against the enormous east-west and west-east components, which should otherwise result in both currents. As soon as an easterly polar current and a westerly tropical current become too strong, a cyclone forms between them and makes the currents encroach upon each other, diminishing their differences of velocity. A polar air particle traveling from pole to Tropics, successively comes under the influence of the different cyclones of the family. Each cyclone deviates the motion of the particle from easterly to northerly or even westerly, so that it again may advance some distance toward the Tropics without obtaining too great a westward velocity component.

A second brake against the great west-east and east-west component acts where a polar current borders a tropical current to the east of it. The two currents, owing to the earth's rotation, will there press together so that they hinder each other from obtaining the velocities to be expected as an effect of the earth's rotation alone. The result of this pressing together appears in an accumulation of air-masses above the region of the mutual limit of the two currents, or in the field of pressure as the formation of a HIGH. This process represents the general formation of moving anticyclones: *A moving anticyclone forms as a boundary phenomenon between the right flank of a polar current and the tropical to the west of it.*

The moving anticyclone is thus formed between two successive cyclone families and follows their motion from west to east round the

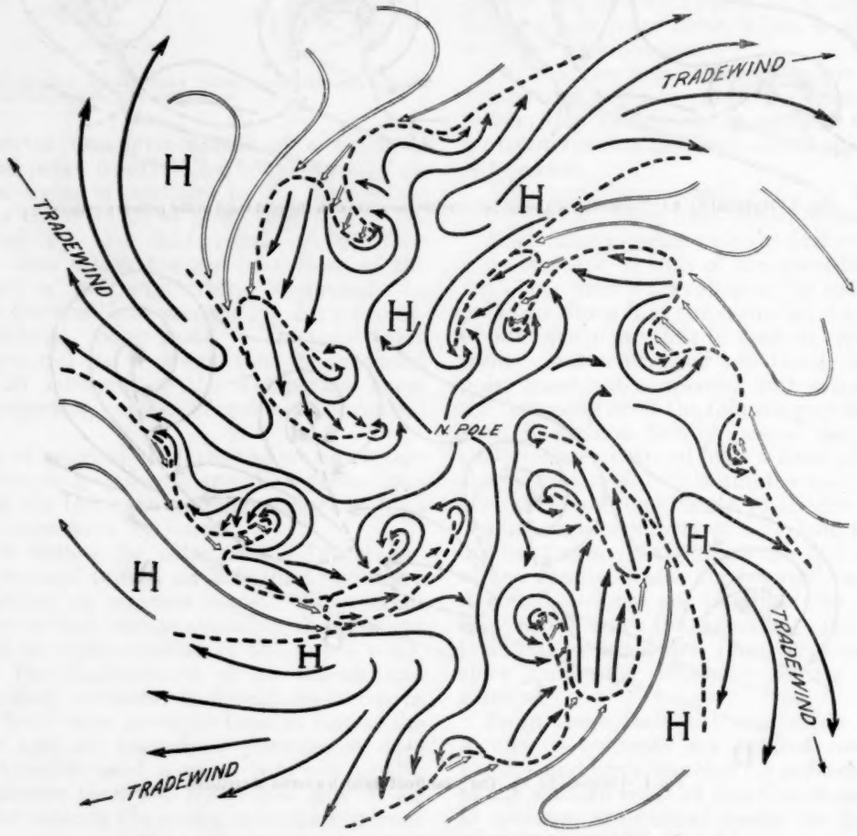


FIG. 6.—[Original fig. 12.] General extratropical circulation of the atmosphere.

[10] Cf. *Geofysiske Publikationer* Vol. II, No. 4, pp. 84–88.

pole, consequently the anticyclone moves with the same speed as the cyclone families, but more slowly than the particular cyclones which during their existence move from the rear to the front of their family.

PERIODS OF METEOROLOGICAL ELEMENTS DUE TO CYCLONE FAMILIES AND MOVING ANTICYCLONES.

Disregarding the obstructions caused by the large continents, cyclone families and moving anticyclones may be imagined to travel continually around the pole.

This movement will produce a periodicity in the meteorological elements throughout the Temperate Zone. Places far north will, for instance, only receive precipitation from the first passing members and places far south only from the last passing members of a cyclone family. Places situated centrally in the cyclone belt, so that they receive precipitation from all the cyclones passing, will have a short spell of fair weather during the passage of the anticyclone which separates successive cyclone families. If the cyclone families perform perfect circuits around the pole,[11] the length of the periods should be equal in all parts of the cyclone belt. They may, however, be of different length in the two hemispheres, as the cyclone families north and south of the Tropics form two independent systems.

A count of the cyclone families passing over Europe in 1921 gives 66 as the total number. This would give a mean duration of 5.5 days, but the authors recognize an error of about 10 per cent.

Various investigators have found short period fluctuations in the climatic elements; probably the most thorough was that of Defant,[12] who found for a single year, 1909, a period of about 5.7 days in the Northern and 7.2 days in the Southern Hemisphere. The cyclone family period of 1921, 5.5 days, agrees so well with the precipitation period from 1909 Northern Hemisphere of 5.7 days that the two periods are considered as identical within the limits of errors.

DISCUSSION.

ALFRED J. HENRY.

The central idea in the foregoing is that cyclones are formed along lines of discontinuity which separate masses of dense polar air from lighter air of tropical origin. The underlying assumption is that the dense polar air is moving westward immediately adjacent to a current of warm air moving eastward. When for any reason the warm current bulges to the northward intruding into the westward moving polar air, the greater density of the latter will cause it to flow along the ground and to cause the warm air to ascend, thereby producing cloud and rain. The condensation of water vapor and the latent heat thus evolved will augment the ascensional movement thus mechanically originated which, together with the modification of the original motion of the air due to the earth's rotation, will create a cyclone. This, in brief, is the reviewer's understanding of the mode of origin of cyclones as advanced by the authors. The various changes which the cyclone undergoes in its brief course has been outlined in the pages preceding.

In view of the fact that the phenomena of cyclones and anticyclones are at best very imperfectly represented on weather maps by surface conditions it must be assumed that the specifications hereinbefore presented should be considered as applying to the conventional cyclone and anticyclone, or possibly to the average of conventional cyclones and anticyclones as they enter Norway.

Forecasters in the United States will be quick to recognize in the specifications hitherto mentioned many familiar phenomena in connection with the movement of cyclones and anticyclones. There are, however, some points of difference between the experience of the Norwegian forecasters and those of the United States; some of these have been mentioned in the series of footnotes appended to this article; others are not easily disposed of within the limits of a footnote. In what follows I shall refer to the most obvious differences between the larger features of the Bjerknes scheme as contrasted with the experience of forecasters in the United States.

Latitudinal differences.—Undoubtedly the origin and development of cyclones and anticyclones are more clearly defined in the latitude of Norway (north 58° to 77°) than in the United States. For the most part cyclones and anticyclones which traverse the latter arrive on its frontiers as fully developed systems of wind circulation. Secondary cyclones, however, frequently develop over the southern and middle portions of the Plateau region in barometric troughs which pass across those regions (from west to east). The development of a primary cyclone, using that term as synonymous with the A-cyclone of the Bjerknes terminology, in the United States is a very rare occurrence.

Cyclone families—The ability to foresee the occurrence of cyclones in families as contemplated in the Bjerknes scheme would be of very great significance in extending the forecasts beyond the conventional period. For reasons indicated in the preceding paragraph it is not only difficult to identify the *A* cyclone of each family on the charts of the United States Weather Bureau, but also, it seems highly improbable from the past experience of forecasters in this country that the occurrence of cyclones in families takes place in the latitudes of the United States with sufficient regularity to make the precept of definite value in long-range forecasting;[13] moreover cyclones at times move southeastward from the Pacific to the Gulf of Mexico and thence northeastward to the St. Lawrence Valley, or develop over the Gulf of Mexico and move similarly, apparently without regard to the development and movement of cyclones along the northern circuit. These cyclones sometimes occur in groups and apparently have no relation to those of the northern groups.

Precipitation.—The area of precipitation in the advance of cyclones in the United States is rarely symmetrically distributed around the front of the cyclone, but is irregularly distributed according to geographic position of the cyclone and the season.

On the Pacific coast and in the Plateau and Rocky Mountain region precipitation occurs as a rule in the rear of the cyclone center instead of the front. On the immediate coast the winds of winter, as is well known are relatively warm as compared with those of the land, and the precipitation that is associated with the movement of the cyclone is of the orographic rather than the cyclonic type. In the Bjerknes type of cyclone the cold air to the eastward of the cyclone is made to curve around the north side of the cyclone and swing in toward the center as a northwest wind. While this movement probably takes place in the conventional cyclone after

[11] The evidence of the Signal Service international series of observations seems to point to a gap in the path of cyclones around the pole as for example over northern Siberia.

[12] A. Defant: Die Veränderungen der allgemeinen Zirkulation der Atmosphäre in den gemässigten Breiten der Erde. *Wiener Sitzber*, 1912, p. 379.

[13] See footnote No. 8 on p. 470.

it advances far inland, the reviewer makes a mental reservation as to just how far this process is fulfilled in nature, especially on the Pacific coast.

In the theory of the formation of anticyclones no account is taken of the effect of radiation. The influence of radiation in the dry regions of the far West is believed to play a large part in the formation and maintenance of anticyclones in that region.

It is freely conceded that the researches of the meteorologists of the Bergen Institute represent a decided step in advance, yet it can not be said that the theory they advance is complete and satisfying. The reviewer's experience as a forecaster leads him to the opinion that for the United States, for example, the occurrence of precipitation in connection with cyclones and anticyclones is not fully explained by the Bjerknes theory; moreover, some doubt has been expressed in an unpublished manuscript by Mr. Herbert L. Choate, of the Drexel (Nebr.) kite station, as to the existence in the Plains States at least, of the cold front and the wind circulation on the front of the idealized cyclone of Bjerknes. In any event further study of the kite and pilot-balloon data now available will doubtless lead to a better understanding of the physical processes involved in the origin and maintenance of cyclones and anticyclones.

FOOT-LAYER DENSITIES OF SNOW.[1]

By H. F. ALPS, Meteorologist.

[Weather Bureau, Reno, Nev., September 19, 1922.]

This special investigation of snow densities was begun in the fall of 1916 and continued each season until its completion in the spring of 1921.

The measurements were made at Summit, Calif., about 40 miles west of Reno, at an elevation of 7,019 feet. Summit station is located near the easterly end of Summit Valley, which is about 3 miles long and 1 mile wide. This valley is fairly well timbered and the rim of the surrounding mountains is approximately 1,000 feet above the valley. This region is considered an ideal location for any kind of snow investigations, as the average annual snowfall is 442 inches, which is the greatest seasonal snowfall recorded in the United States. Moreover, the snowfall is comparatively free from drifting effects and therefore the snow cover is remarkably uniform in depth. The run-off from snow fields for irrigation and hydroelectric purposes is undoubtedly greater than from any other region in the United States. Fifteen miles to the southeast, and approximately 800 feet lower, lies Lake Tahoe, the largest body of fresh water at that elevation in the United States.

The work represents a total of 24 trips to Summit, during which 659 measurements were made. The first five trips were made by H. F. Alciatore and O. H. Hammonds, and beginning with April, 1917, the work was carried on by the author and O. H. Hammonds.

TABLE 1.—*Dates of trips and total depth of snow cover in inches.*

Season.	November.		December.		January.		February.		March.		April.		May.	
	Date.	Depth.	Date.	Depth.	Date.	Depth.	Date.	Depth.	Date.	Depth.	Date.	Depth.	Date.	Depth.
1916–17	29	8.8	30	59.0	30	87.8	27	154.8	15	168.0	30	107.0	29	37.0
1917–18	30	2.9	.....	.....	2	5.8	26	82.5	.....	.....	9	66.5	1	23.0
1918–19	.....	.....	31	23.0	31	49.0	.....	.....	5	122.0	8	88.0	7	33.2
1919–20	.....	.....	31	39.0	.....	.....	.....	.....	5	68.0	13	66.0	13	36.0
1920–21	.....	.....	.....	.....	14	64.0	.....	.....	17	97.0	29	63.0	.....	.....

Note.—Measurements taken at Summit, Calif., elevation, 7,019 feet.

The primary object of the investigation was to test the accuracy of the Wengler formula [2] and ascertain whether the formula has any practical working value. This formula states in substance that the density of any given layer of snow bears a certain relation to the density of the top layer, depending upon the depth of the given layer below the surface. After starting the investigation, it was found that an excellent opportunity was given for the study of the snow cover throughout the entire season. Therefore, it resolved itself into the determination of the density of each 12-inch layer from the ground up.

For this work the following instruments were used: A Weather Bureau snow sampler 16 inches long and 4.002 inches in diameter, a Weather Bureau spring balance weighing in fiftieths of a pound, and a piece of apparatus called a "snow slicer" made of galvanized iron, about 14 by 14 inches, with a sharp semicircular edge on the side opposite two wooden handles. In order to make layer measurements, a smooth vertical section of the entire snow cover was obtained by digging a trench. The 12-inch layers were then marked on the face of this section, beginning at the ground. The snow slicer was inserted first beneath the top layer, and the density of this layer was determined with the sampler. The snow above the slicer was then removed and the density of all succeeding layers was determined in like manner. As the slicer formed the bottom of each layer while being sampled, accurate foot-layer measurements were obtained. Two or three samples of each layer were taken and the resulting average used in all cases.

During the season of 1916–17 seven trips were made to Summit beginning with November. This was the season when the snow cover reached its greatest depth, 168 inches on March 15. Table 1 shows the remarkable uniformity in the monthly increase of the snow cover from November to February, and decrease from March to May. This was an ideal season for snow work and it was fortunate that density measurements were started during this season. As the snowfall during this season was practically normal both as to time of occurrence and amount, the records are considered of greater value than those of any other season during which measurements were made.

Five trips were made to Summit during the season of 1917–18. This was an unusual year. The highway over the summit was open until January 12, when it was closed by 32 inches of snowfall. The snowfall for the season to January 12 was the least on record, and it was the only year in the memory of oldtimers when the highway was open on New Year's day. On November 3, 1917, the depth of snow was 2.9 inches, and on January 2, 1918, the depth was 5.8 inches. (Fig. 1.) February storms were moderately heavy, and on the 26th a depth of 82.5 inches of snow was measured. (Fig. 2.) The results of each trip are given in Table 2.

[1] Cf. H. F. Alciatore, Layer measurements of snow on ground near Summit, Calif. Mo. WEATHER REV. 48: 519–520.

[2] Wengler, Fritz: *Die Spezifische Dichte des Schnees*. Berlin, 1914.

FIG. 1.—Bare ground at Summit station, January 2, 1918.

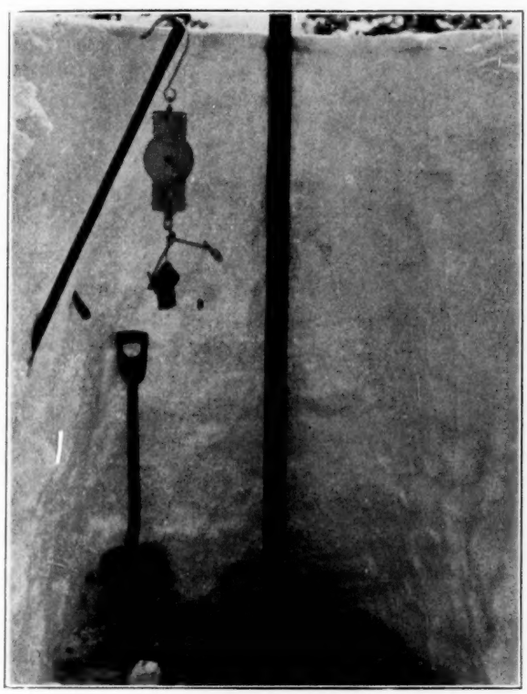


FIG. 2.—Vertical section of snow showing depth of 82.5 inches February 26, 1918.

FIG. 3.—Open park where measurements were made.

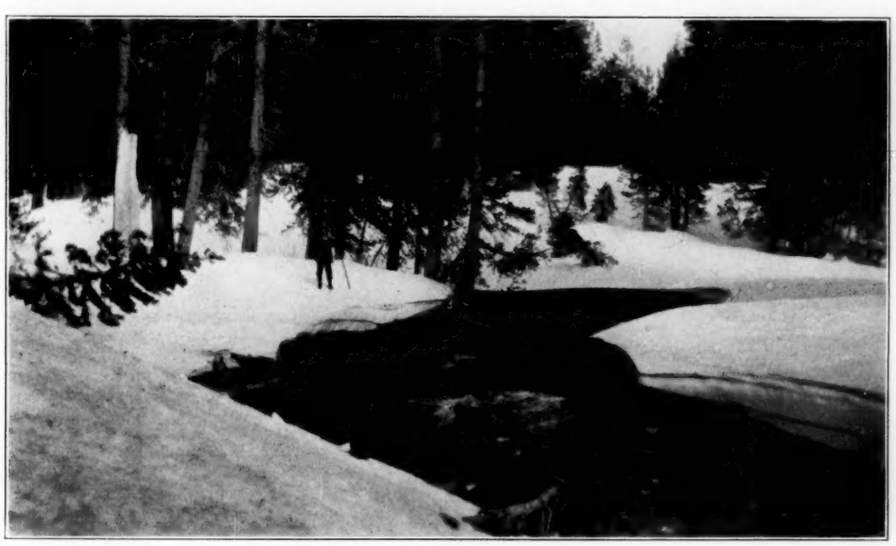


FIG. 4.—Illustrating run-off beneath snow cover, Summit, Calif.

TABLE 2.—*Snow density by 1-foot layers ground up at Summit, Calif.*

(Percentage of equivalent water.)

Year.	Ground to 1 foot.	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 8	8 to 9	9 to 10	10 to 11	11 to 12	12 to 13	13 to 14
1916–17.														
November	21													
December	37	37	29	27	13									
January	42	38	40	36	32	28	18	18						
February	43	44	42	40	38	34	34	31	29	28	25	31	18	
March	43	42	44	43	40	38	40	41	37	38	26	19	17	10
April	55	45	48	51	55	53	55	55	50					
May	61	50	62											
1917–18.														
November	43													
December														
January	36													
February	43	32	28	24	24	22	16							
March	52	49	54	48	46	47								
April	46	54												
1918–19.														
December	30	25												
January	34	30	28	24										
February														
March	37	34	39	37	39	37	30	25	26	22				
April	43	44	47	45	50	50	47							
May	50	49	48											
1919–20.														
December	36	32	35											
January														
February														
March	47	45	53	32	28	20								
April	51	48	52	45	48	41								
May	55	58	54											
1920–21.														
January	41	47	49	44	33	24								
February														
March	48	51	48	42	49	46	46	43						
April	46	52	52	47	53									

During the season of 1918–19 five trips to Summit were made, the first being on Decebmer 31, when the depth of snow was 23 inches. The January snowfall was light, but the snowfall during February was heavy and a depth of 122 inches was measured on March 5, which was the greatest of the season.

Four trips were made to Summit during the season of 1919–20, the first being on December 31, when the depth of snow was 39 inches, and the ground was frozen to a depth of 1 inch. As the snowfall was light in January and the first half of February, the next trip was delayed until March 5, when there was a depth of 68 inches on the ground. At this time the ground was well moistened and not frozen. On April 13 the depth was 66 inches, and it was 36 inches on May 13.

Only three trips to Summit were made during the season of 1920–21. The first measurements for this season were made on January 14, when the snow cover was 64 inches. The maximum depth of the season was 97 inches on March 17, and a depth of 63 inches of snow remained on the ground on April 29. The density of the snow cover in January was much greater than usual.

The layer measurements prove that it is impossible to determine the density of the whole snow cover from the density of a layer on the surface. Wengler himself stated that in deep snow there are such breaks in uniformity that a perfect law can not be established. This lack of uniformity in density is due to weather conditions during the accumulation of the snow cover. In the interval between storms crusts of varying thickness and density are invariably formed, and such crusts were encountered each season in the work at Summit. These crusts varied from a fraction of an inch to 10 inches in thickness, and some of them were almost solid ice in formation. The density of a layer of snow where incrustation was found was considerably greater than adjacent layers with no incrustation. By noting the relative position of certain crusts at different times, *it was proved that the snow disappears simultaneously from the top and the bottom.*

The mean density for the whole snow cover at Summit, Calif., as determined by the five seasons of investigations, is as follows:

December.	January.	February.	March.	April.	May.
32	34	34	40	49	54

Five years is a short period to establish accurate means, yet it is believed that records covering a longer period of time would not change these values materially. Therefore, it is believed the water content of the snow cover at Summit, Calif., and adjacent regions can be determined approximately at any time of the season by applying these average densities to the depth. Whether or not these values would hold good for other regions could be determined only by investigations in those regions.

This is the first detailed study of a snow cover during several consecutive seasons that has been made in this country, and the records obtained should add much to our limited knowledge of snow densities.

A SIMPLE SNOW-DENSITY MEASURER.[1]

By W. W. KORHONEN.

[Translation by H. C. Frankenfield.]

With the cooperation of Prof. G. Melander, I have constructed for the determination of snow density a new measurer with which observations can be made much more rapidly and simply than hitherto, and the measurements can be made in the open air. It consists of a cylinder 50 cm. in height, with a cross section of 100 cm.^{2}, a shovel, a sliding weight balance, and a hook by which the cylinder is attached to the balance. The balance has an arm 48 cm. in length, and the prisms, which are 4 cm. apart, can be pressed together for transportation by means of two screws. The sliding weight weighs 200 g., wherefore a snow mass of 10 g. (= 1mm. water depth) corresponds to a length of 2 mm. on the scale. The balance arm can be brought into a horizontal plane by means of an indicator fastened to one of the prisms, whereupon the reading will be found at the end of the sliding weight. The balance turns the scale distinctly for a weight of 2 g., which corresponds to the water content of a layer of snow about 1 mm. in thickness. For transport the balance and hook are placed in the cylinder and this, together with the shovel, are packed into a narrow sack. The observation is so carried out that the cylinder, after the snow sample has been cut in the prescribed manner, is overturned, fastened with the hook to the balance, and weighed, so that the lid of the cylinder serves as a bottom.

There was freedom from the earlier errors of evaporation by reason of careless melting of the snow, the adhe-

[1] Meteorologische Zeitschrift, June, 1922.

sion of melting snow to the walls of the vessel, as well as the possibility of accident during transport and the later handling of the sample. The composition of the different snow layers was also easily studied with the new instrument. The measurer constructed by Polis for this purpose did not give good results, inasmuch as the sinking of the snow by reason of the simultaneous cutting out of the samples worked badly.

At the end of January I made measurements with the new instrument, part of the time northward from Helsinki in a wide, unprotected field, part of the time in thick woods or in larger clearings. Everywhere the snow was granular and the snow cover consisted of several layers. Beneath lay a thick layer of coarse snow with a maximum thickness of 15 cm. that offered strong resistance to the measuring cylinder. This occurred very generally in the woods, but was encountered only sporadically in the field. Then followed several thinner layers of finer or coarser snow, and above lay a fairly uniform stratum of from 10 to 25 cm. thickness which was covered with a thin crust of smooth ice.

When the thin intermediate layers were summarized we obtained the following results for all of the places in which separate measurements were made:

	Open field.			Woods and clearings.			All places.		
	Depth.	Water content.	Density.	Depth.	Water content.	Density.	Depth.	Water content.	Density.
	cm.	*mm.*		*cm.*	*mm.*		*cm.*	*mm.*	
Upper layer	12.9	33.4	0.262	20.9	43.8	0.210	17.8	39.7	0.223
Intermediate layer	15.0	39.7	0.265	16.9	47.7	0.282	16.2	44.8	0.276
Surface layer	1.7	5.5	0.322	11.2	31.4	0.278	7.6	21.5	0.283
Entire snow cover	29.6	78.6	0.265	49.0	122.9	0.251	41.6	106.0	0.255

The increase in snow density from above downward shows here no such regularity as could be demonstrated mathematically, for example, but nevertheless the mean for a number of years was computed. In single instances these stand out, as, for example, in a clearing where six layers were measured, whose depth and density from above downward were as follows:

	1	2	3	4	5	6
Depth (cm.)	21.0	4.0	4.0	2.8	5.5	10.0
Density	0.220	0.343	0.250	0.253	0.282	0.238

To a certain extent the snow cover reveals a history of the weather during the presence of the snow. The layers, 2, 4, and 6 fell and existed during thawing weather, with very large grains, except the last. It should be noted that the density of the lower, quite hard layer was only a little greater than that of the moderately soft upper ones. Thus the structure of the snows in this respect appears to play a more important rôle than the absolute differences in density.

The maxima and minima of the entire snow cover were as follows:

	Open field.			Woods and clearings.		
	Depth.	Water content.	Density.	Depth.	Water content.	Density.
	cm.	*mm.*		*cm.*	*mm.*	
Maximum	39.5	110.7	0.287	57.5	140.7	0.260
Minimum	24.0	61.6	0.222	19.5	69.5	0.193

The measurements in the clearings show the most uniform results, as was to be expected. There the density varied only from 0.260 to 0.241, and the mean differed but little from the general means.

That the density in the field was greater than in the protected places is entirely due to the packing together of the snow by the wind, and it is most significantly marked in the upper layers, because the hard surface layer is almost entirely absent. However, the influence of the age of the snow cover is apparent in the woods, because in those places where the surface layer was thickest as a whole, the density of the whole snow cover reached a higher value than otherwise. Because of the much smaller snow depth the water content in the field was less than in the protected places, despite the greater density.

The difference between the protected and unprotected places of observation, namely, 19.4 cm. (depth) and 44.3 mm. (water content) distributed themselves in the upper, middle, and lower layers in the following manner: Upper layer, 8.0 cm. and 10.4 mm.; middle layer, 1.9 cm. and 8.0 mm.; the lower layer generally 9.5 cm. and 25.9 mm. Since the differences between the various places of observation are such that the snow collects in one place better than in another, or the decrease of the snow through thawing weather occurs mainly because of the varied influence of the different winds, the highest and lowest layers here come under consideration. This becomes evident during a cold period, and the difference, corresponding mainly to the varied accumulation of the snows, dates from the first periods of the snow cover, where decided thaws eat up the snow in great measure. Their differences thus make essentially clear the last-mentioned viewpoint, wherein consideration must also be given to the fact that over the field less snow has fallen originally than over the protected areas, about in the same proportion as the upper layer yielded. The effect of the thawing weather is thus stronger than that of the remaining factors, although the air temperature during the existence of the snow cover has fallen below the normal. The average proportions result first from several years' observations. In mild winters the influence of thawing weather easily predominates, whereas in cold winters the different deposits of the snows become of more importance. In the Southwest the former, in the East and North the latter factor is the stronger, and after the early year the thawing weather and the sunshine play an increased part.

CLIMATIC PHENOMENA.

By E. N. MUNNS.

[U. S. Forest Service, October 12, 1922.]

In studying the distribution of general vegetation, ecologists generally are interested in the climatic factors, as these are a matter of simple and general record, and widespread observations of them have been made for many years throughout the country. Many of these records obtained by the Weather Bureau extend over such a period of years and are so thoroughly reliable that one is warranted in using them as a basis for conclusions as to the distribution of plants.

The principal climatic factors which have to do with the occurrence of types of vegetation are precipitation and temperature for, with a sudden change in either element the types change markedly. Generally speaking, ecologists are concerned with the length of the growing season, precipitation during the growing season, and maximum and minimum temperatures.

The length of the growing season is of importance because it decides whether a given species will be able to ripen and mature its fruits upon which its ability to reproduce depends. Upon the precipitation available during the growing season depends the rate of growth and the ability of the plant to survive long enough to mature fruit. Maximum and minimum temperatures also become limiting factors when the temperatures become excessively high or excessively low. The former is important when it induces wilting because of too rapid transpiration, and the latter when it interferes with growth as in the case of frost damage.

In order to arrange the Weather Bureau data for comparative analysis, it has been found convenient to develop a chart which combines simplicity with use. The construction of this chart is shown graphically in Figure 1, being a series of concentric circles, which are used in this case to indicate the precipitation in amounts of 0.50 of an inch. In order to represent the months, 12 radii are drawn in, equally spaced, and the months arranged clockwise. The precipitation is then plotted by months out from the center on these radii and then connected together, forming an irregular, 12-sided polygon.

As is shown in the right-hand chart in Figure 1, the temperature chart is made up in a similar fashion, using each circle as a 5° interval, and with 20° as the center. On this series of circles the temperature is plotted, forming a second irregular-shaped polygon. When temperatures are below 20°, it is necessary to plot the points below the center, rather than above it, in order to complete the figure. As the growing season begins and ends at about 40°, and the best plant growth is made at a temperature of about 60°, the two circles representing those temperatures are made slightly heavier to make them stand out more prominently as an aid in reading the chart. The points where the perimeter of the temperature polygon crosses the 40° line are assumed to be the beginning and end of the growing season. By drawing a line out from the center to cross the intersection of these lines, the growing season is separated from the dormant period. By plotting this point on the first circle the precipitation is then divided into that occurring in the two seasons; that falling during the dormant period then can be set off from the rest by crosshatching the latter.

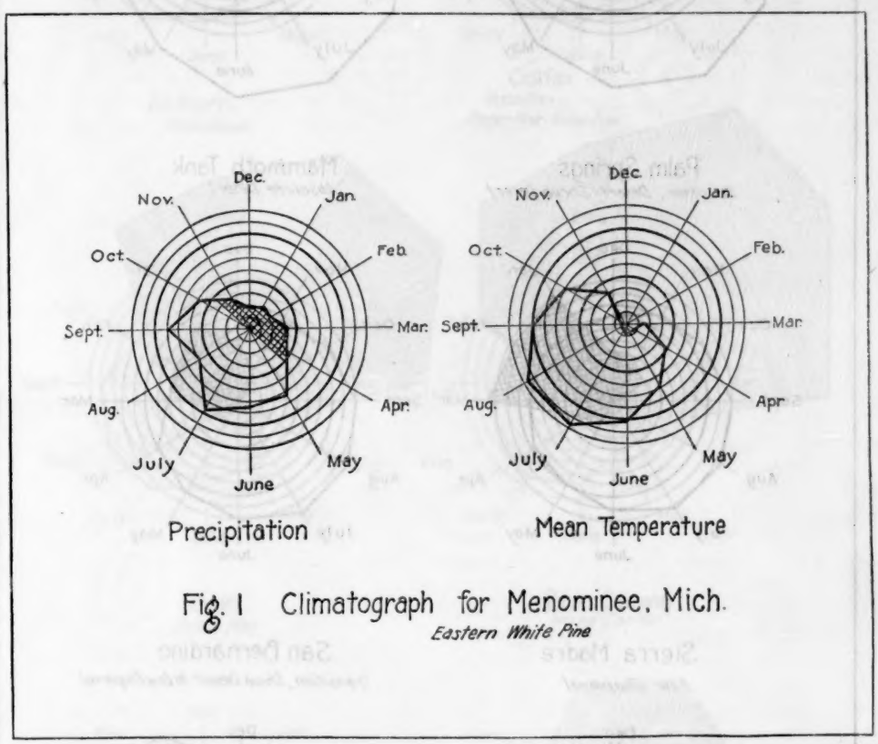


Fig. 1 Climatograph for Menominee, Mich.
Eastern White Pine

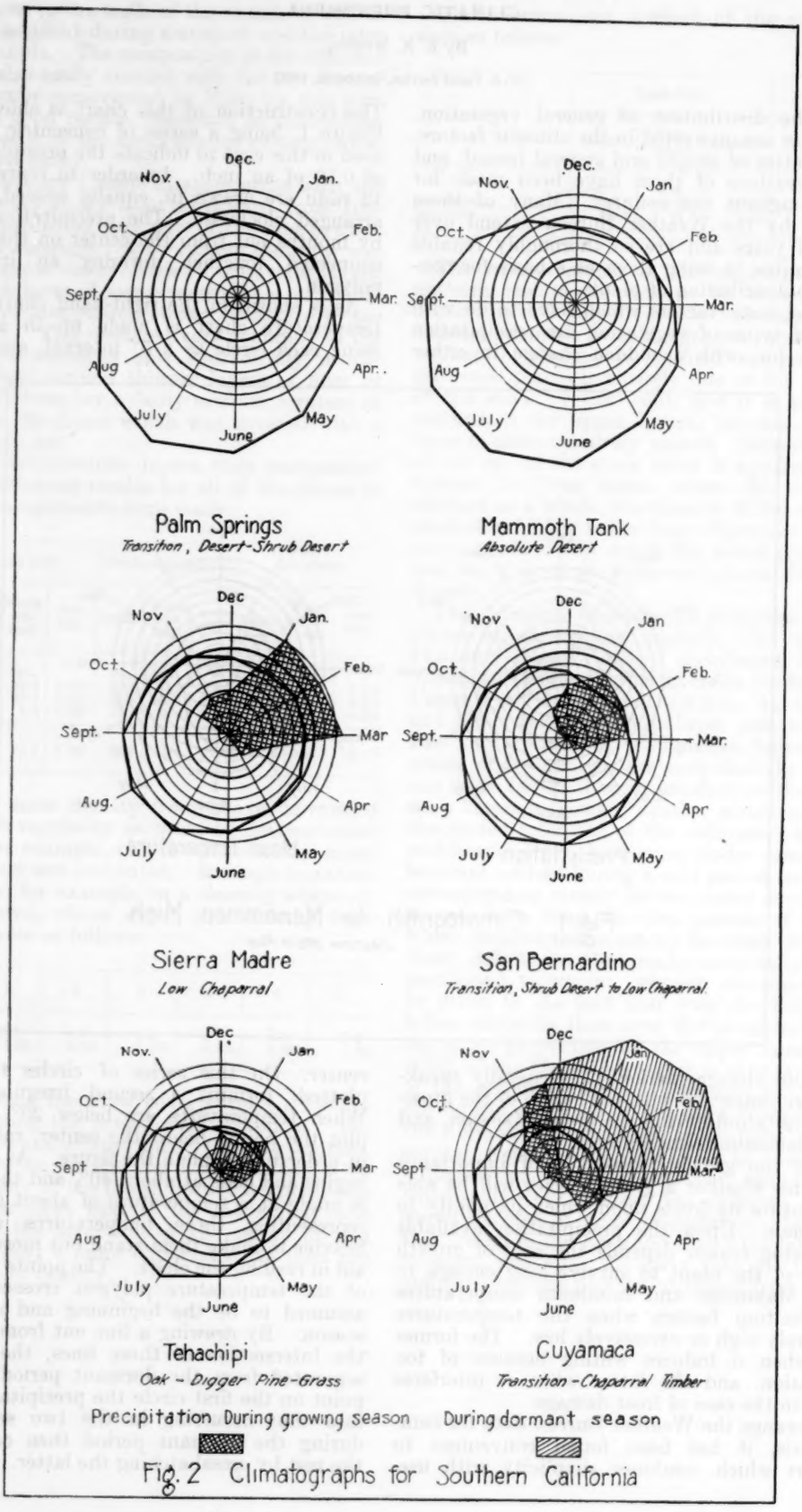


Fig. 2 Climatographs for Southern California

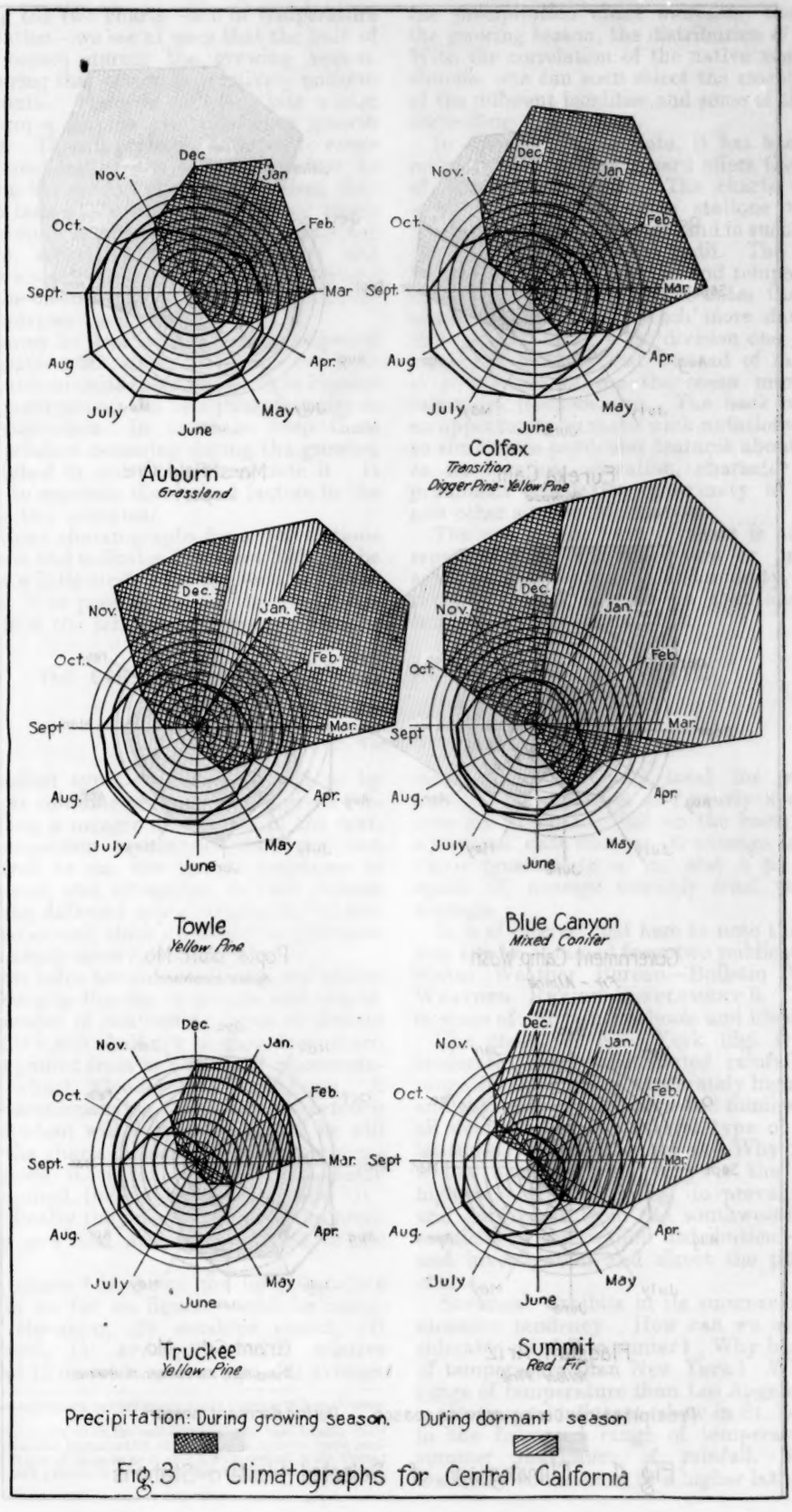


Fig. 3 Climatographs for Central California

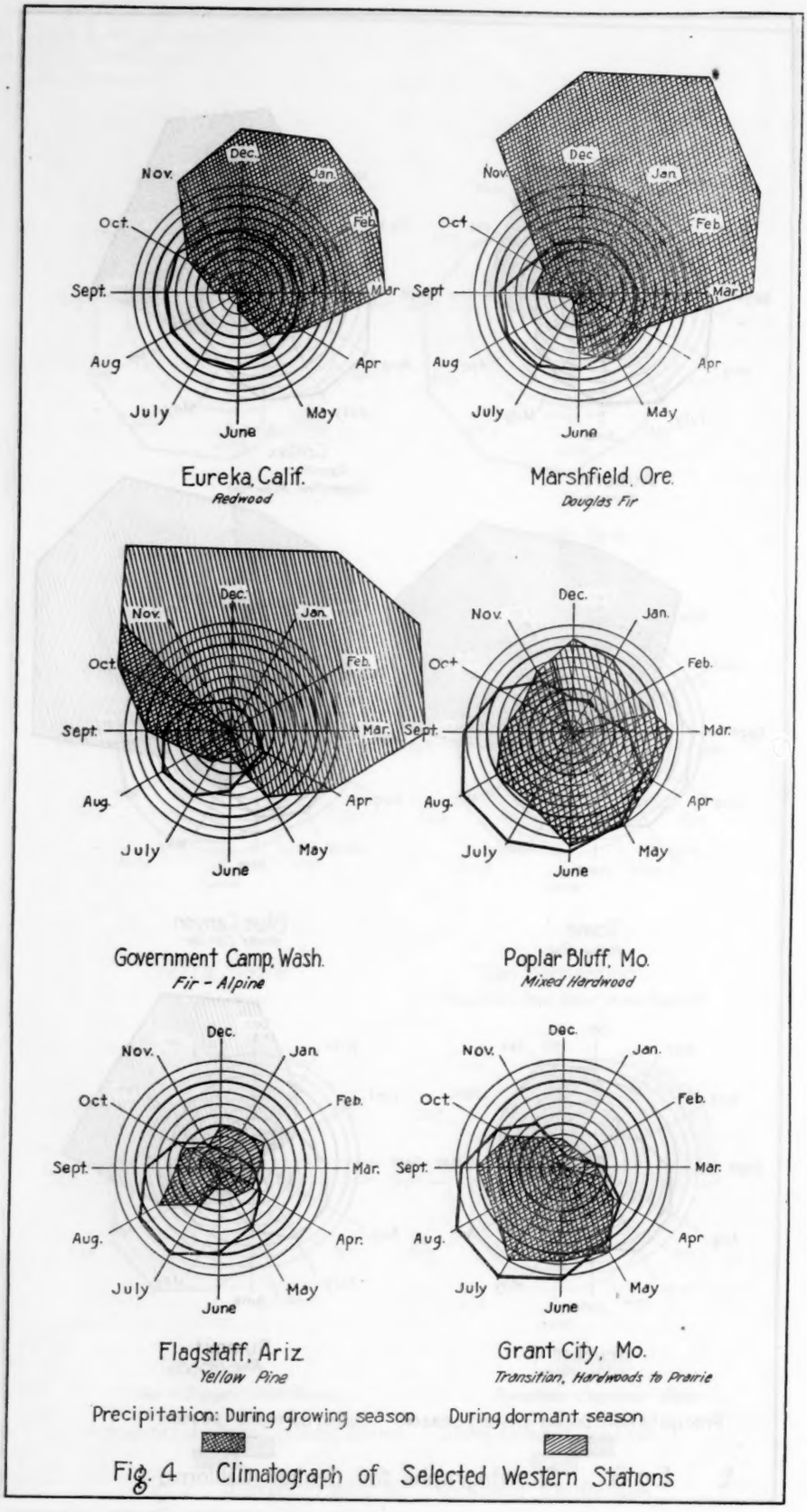


Fig. 4 Climatograph of Selected Western Stations

Thus in studying the two charts—one of temperature and one of precipitation—we see at once that the bulk of the precipitation occurs during the growing season. The distribution during this season is relatively uniform from month to month. There is sufficient late winter precipitation to form a surplus available when growth begins in the spring. There is probably snowfall to cover the soil, thereby ameliorating the soil temperature to some extent. From the second chart it is evident that the growing season lasts about six months during which the average temperature is about 55° or 60°, while the winters are severe, especially during December and January. There is a small spread in the range of annual temperature, and the mean annual temperature—roughly the center of the polygon—is about 42°.

To have two figures to deal with is rather awkward and entails considerable work, so that it has proved both feasible and practicable to unite them, as shown in Figures 2, 3, and 4, by superimposing the temperature polgyon upon that of precipitation. In order to keep these separate, the precipitation occurring during the growing season is cross hatched in order to differentiate it. It then becomes easy to separate the desired factors in the comparison of any two climates.

Figure 2 shows these climatographs for a few stations in southern California and indicates the uses which can be made of them. By a little study of many such figures as shown in Figure 3, it is possible to see the gradations between stations; how the temperature chart contracts, the precipitation chart increases, the development of the growing season, the distribution of the precipitation. With the correlation of the native vegetation with each climate, one can soon select the essential characteristics of the different localities and some of the limiting factors controlling distribution.

In compiling these data, it has been found that the ordinary 3 by 5 library card offers the best opportunity of comparing stations. The charts usually fit nicely upon these, except some stations where the winter precipitation is tremendous, and in such cases the amounts can be written upon the radii. The use of two colors brings out the precipitation and temperature data better than the one color, and obviates the necessity for so much crosshatching. Much more data can be put on these charts, making the division one of 10-day periods instead of months and, instead of mean temperatures, it is possible to use the mean maximum and mean minimum temperatures. The back of the cards offers an opportunity to make such notations as are desired, or to enumerate particular features about the station, such as its location, elevation, character of crops grown, prominent vegetation, proximity of bodies of water, and other similar information.

The use of this form of chart is not confined to the representation of temperature or precipitation alone, as it has been used also with humidity, pressure, evaporation, and other phenomena that one might desire to compare on a monthly basis.

THE USE OF CHARTS AND GRAPHS IN THE STUDY OF CLIMATE.[1]

By VERNA B. FLANDERS.

[Clark University, Worcester, Mass., August, 1922.]

When I first studied types of climate, I did so by steadfastly gazing at columns of figures for a given station and then reading a meager description in the text. No thought of comparison or contrast with my own environment occurred to me, few human responses to climate were suggested, and, altogether, no very definite mental picture of the different types remained with me. Perhaps this was just as well, since I was later to approach the subject from a much more interesting angle.

One of the greatest helps toward visualizing and understanding climatic data is the use of graphs and charts. I have chosen a number of contrasting types of climate from our own country and shall try to show how much information can be gained from two types of representation—the climatic chart (Goode) and climograph. A hasty glance at the accompanying diagrams reveals much of value, but the student will find added help if he will actually construct the charts himself and will experiment with graphs he finds most helpful. The knowledge needed, the care required, the interest in seeing how "it" is coming out, and finally the interpretation of the product—all lead to a new and absorbing interest in the subject.

On the climatic charts [2] is shown the following data for each station in so far as figures could be found: (1) Location, (2) elevation, (3) sunshine record, (4) wind-direction record, (5) average monthly relative humidity (8 a.m. and 12 m. readings average), (6) average monthly rainfall and total for year, (7) average monthl ytemperatures and yearly averages. These figures are entered in full on the back of each chart with additional data such as (1) average monthly and yearly vapor pressure (8 a. m. and 8 p. m. readings averaged), (2) average monthly wind velocity and yearly average.

It is of interest just here to note that all this information can be obtained from two publications of the United States Weather Bureau—Bulletin W and MONTHLY WEATHER REVIEW SUPPLEMENT 6. They are available in some of our larger schools and libraries.

The chart for New York (fig. 1) shows the city's moderate, evenly distributed rainfall, the fairly large range of temperature, moderately high relative humidity, and the delayed maximum and minimum temperatures—all evidences of our littoral type of climate in middle latitudes. Such questions as—Why has February such a low temperature? Why is the relative humidity highest in winter? Why do prevailing winds in June and July come from the southwest? Account for the evenness of the rainfall distribution—stimulate thought and investigation and direct the pupil's study of the charts.

Savannah exhibits in its summer rainfall an almost monsoon tendency. How can we account for the considerable rainfall in winter? Why has it a smaller range of temperature than New York? Why has it a greater range of temperature than Los Angeles?

Continental influences show in St. Louis's chart (fig. 1) in the increased range of temperature and the early summer maximum of rainfall. Williston is more markedly continental in a higher latitude.

[1] Thesis submitted in course on climatic environments, Clark Summer School, Worcester, Mass., August, 1922.

[2] The charts here referred to are drawn on the well-known Goode base climatic chart No. 80. Lack of space prevents the reproduction of all of them, but we have combined the essential features of four of them so as to give a cross section of the United States about latitude 40 N. and present it in fig. 1. The climographs appear in fig. 2.—ED.

Denver (fig. 1) shows the influence of increased elevation as well as an interior position in the continent. It shows clearly a light rainfall with a spring maximum, low relative humidity, and a marked seasonal temperature range.

Phoenix is a type of our middle latitude arid regions and its extremely low relative humidity, great temperature range and meager rainfall are striking. Why has it a greater temperature range than Los Angeles? Smaller than Williston? Account for the winter rainfall.

Our Pacific coast furnishes examples of the marine type in San Francisco (fig. 1) and of the Mediterranean type in Los Angeles. Both show the winter maximum

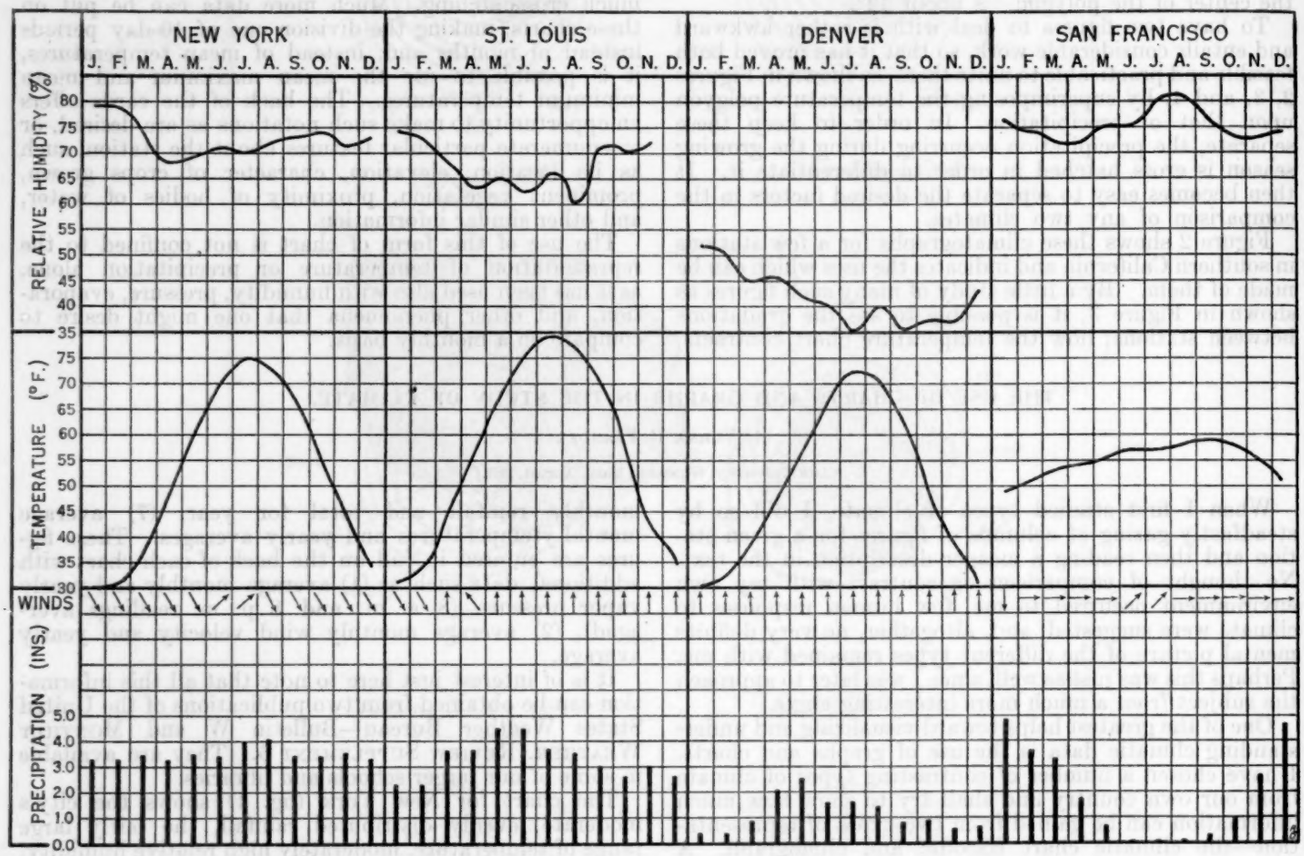


FIG. 1.—Climatic charts of New York City, St. Louis, Denver, and San Francisco. These charts were originally drawn on the Goode base, but, for facility of reproduction have been redrawn.

of rainfall and small temperature ranges. Why does Los Angeles have so much less rainfall? Why are its temperatures higher? Why is its relative humidity lower? Why is not June the hottest month in each case?

A chart for each type of climate to accompany the climatic regions map (Jones and Whittlesey) illuminates the text for beginners in climate study.

The climograph has lately been developed and put to use by Dr. Griffith Taylor, an Australian geographer in his study of The Geographic Representation of the Effect of Climate on Man and The Control of Settlement by Humidity and Temperature.[3]

He plots in graph form the wet-bulb temperature readings (average monthly) and the average monthly relative humidity for the given station. The resulting figure falls into the classification of scorching, muggy, keen or raw, according to its position on the diagram. (See fig. 2).

While this form is graphic, easily readable, and offers opportunity for comparison of stations, it is critized on several counts. First, it seems that *wet-bulb* readings combined with relative humidity give too great prominence to the moisture element in climate. Second, the terms "muggy," "keen," "raw," and "scorching" are relative terms. They mean different degrees to different persons, and, for instance, would doubtless have a slightly different interpretation with us than with an Australian. Third, since climographs for a single place differ from year to year, they might be more valuable for short-term observations—in short, as a help for weather observations rather than for climatic study. Fourth, these graphs take no account of wind velocity, an element that influences greatly the cooling power of the air.

Their chief value seems to be the opportunity they afford for comparison and contrast of different stations. They may be made one of the criteria for determining the limits of a *climatic region*.

A hythergraph (fig. 2, upper left) shows average monthly rainfall and average monthly temperatures. I have chosen five of our eight United States stations to

[3] cf MO. WEATHER REV., September, 1919, 48, 490-495; September, 1920, 49, 495-497.

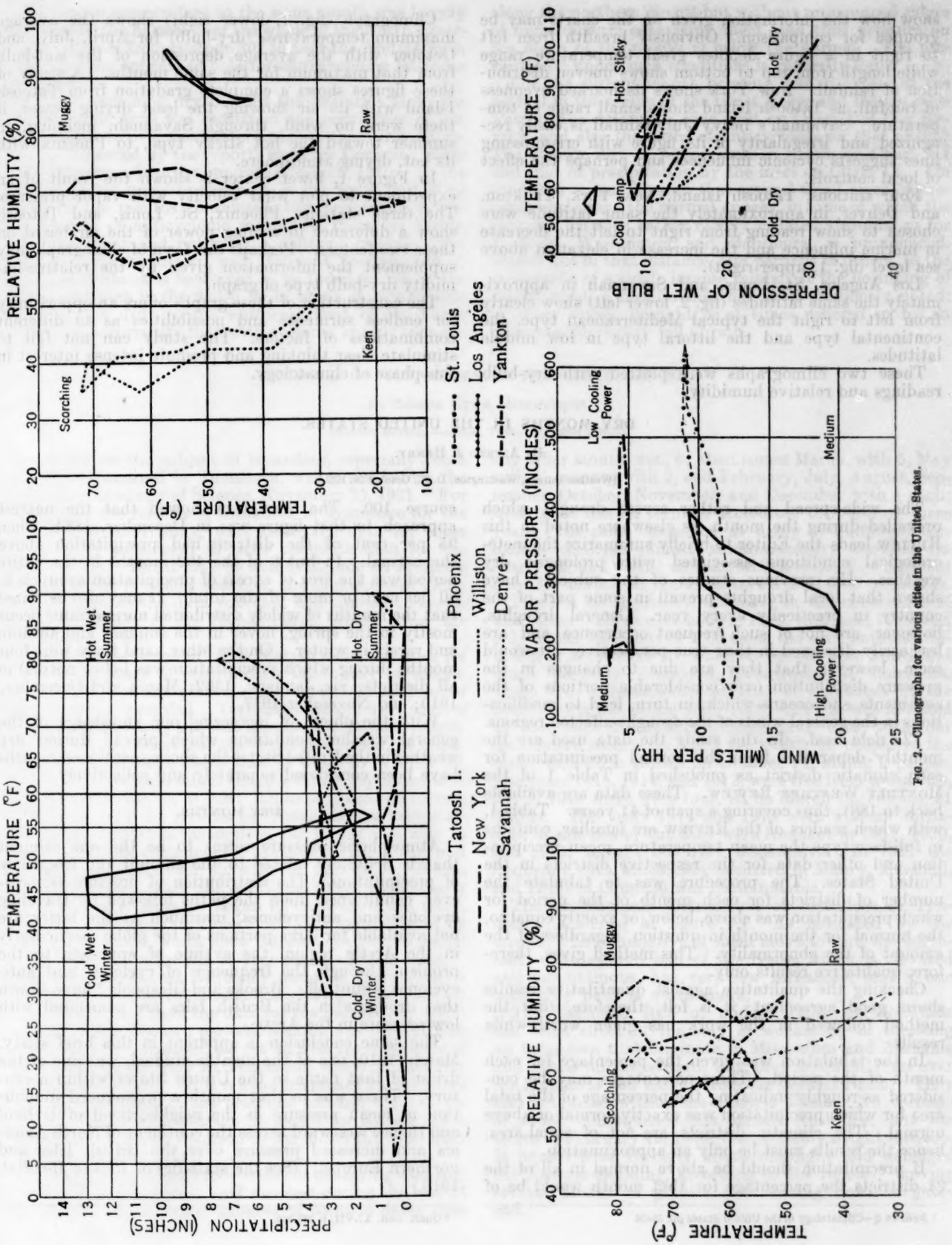


FIG. 2.—Climographs for various cities in the United States.

show how the information given on the charts may be grouped for comparison. Obviously breadth from left to right in a figure denotes great temperature range while length from top to bottom shows uneven distribution of rainfall. New York shows its marked evenness of rainfall, as Tatoosh Island shows small range of temperature. Savannah's heavy July rainfall is easily recognized and irregularity of its figure with crisscrossing lines suggests cyclonic influences and perhaps the effect of local controls.

Four stations, Tatoosh Island, New York, Yankton, and Denver, in approximately the same latitude were chosen to show reading from right to left the decrease in marine influence and the increase in elevation above sea level (fig. 1, upper right).

Los Angeles, St. Louis, and Savannah in approximately the same latitudes (fig. 2, lower left) show clearly from left to right the typical Mediterranean type, the continental type and the littoral type in low middle latitudes.

These two climographs were plotted with dry-bulb readings and relative humidity.

Climograph (fig. 1, lower right) shows the average maximum temperatures (dry-bulb) for April, July, and October with the average depression of the wet-bulb from that maximum for the same months. A study of these figures shows a complete gradation from Tatoosh Island with its air showing the least drying power, if there were no wind, through Savannah, inclining, in summer toward the hot sticky type, to Phoenix with its hot, drying atmosphere.

In Figure 1, lower center is shown the result of an experiment to plot wind velocity with vapor pressure. The three stations, Phoenix, St. Louis, and Tatoosh show a difference in cooling power of the air based on these two factors. Perhaps this form of climograph may supplement the information given by the relative-humidity dry-bulb type of graph.

The construction of these graphs offers an opportunity for endless surmisses and possibilities as to different combinations of factors. The study can not fail to stimulate clear thinking and promote intense interest in this phase of climatology.

DRY MONTHS IN THE UNITED STATES.

By ALFRED J. HENRY.

[Weather Bureau, Washington, D. C., October 28, 1922.]

The wide-spread and rather severe drought which prevailed during the month, as elsewhere noted in this REVIEW leads the Editor to briefly summarize the meteorological conditions associated with prolonged dry weather. His previous studies of the subject [1] have shown that local droughts prevail in some part of the country in practically every year. General droughts, however, are not of such frequent occurrence and are less easily discussed in their true perspective. It would seem, however that they are due to changes in the pressure distribution over considerable portions of the continents and oceans which, in turn, lead to modifications in the general winds of the drought-affected regions.

The data used.—In this study the data used are the monthly departures from the normal precipitation for each climatic district as published in Table 1 of the MONTHLY WEATHER REVIEW. These data are available back to 1881, thus covering a span of 41 years. Table 1, with which readers of the REVIEW are familiar, contains in full-face type the mean temperature, mean precipitation and other data for the respective districts in the United States. The procedure was to tabulate the number of districts for each month of the period for which precipitation was above, below, or exactly equal to, the normal for the month in question, regardless of the amount of the abnormality. This method gives, therefore, qualitative results only.

Checking the qualitative against quantitative results shows good agreement; it is felt, therefore, that the method followed in the work has given worth-while results.

In the tabulation was given the percentage for each month of the period. These percentages may be considered as roughly indicating the percentage of the total area for which precipitation was exactly normal or above normal. The climatic districts are not of equal area, hence the results must be only an approximation.

If precipitation should be above normal in all of the 21 districts the percentage for that month would be of course 100. The tabulation showed that the nearest approach to that figure was in December, 1884, when 95 per cent of the districts had precipitation above the normal. In but 8 of the 492 months in the entire period was the area of excess of precipitation as much as 80 per cent or more of the total. It may also be noted that the months of widely distributed normal rains occur mostly in the spring, never in the summer and autumn and rarely in winter. On the other hand there were four months during which precipitation was below normal in all districts, viz, January, 1902; March and December, 1910; and November 1917.

With the object of increasing our knowledge of the general weather conditions which prevail during dry weather in the United States the above-mentioned months have been considered separately and collectively.

DRY MONTHS.

Atmospheric pressure seems to be the one element that is definitely related to the amount and frequency of precipitation. The distribution of pressure is, however, conditioned upon the paths followed by traveling cyclones and anticyclones; inasmuch as the latter are not available for large portions of the globe, particularly in the Arctic region, the avenue of approach to the problem through the frequency of cyclones and anticyclones is shut off. Brooks and Glaspoole [2] have shown that droughts in the British Isles are associated with low pressure in the Arctic.

The same conclusion is apparent in this brief study. March, 1910, one of the months studied, was one of the driest of that name in the United States within a century. There was in that month a pronounced diminution in mean pressure in the neighborhood of Iceland and thence westward across the continent of North America and increased pressure over the British Isles and northern Europe. (See the statistics of *Reseau Mondial*, 1910.)

[1] *Bulletin Q*—Climatology of the United States pp. 51–58.

[2] Quart. Jour. XLVII, p. 139–166.

The mean temperature in the same month was largely in excess of the normal over the whole of the North American Continent from latitude 30° to near the Arctic Circle, and the same appears to hold for corresponding latitudes in Europe.

In the remaining dry months the deviation from the March, 1910, type was mostly in the occurrence of low mean pressure over the western part of the North Atlantic, as evidenced by the reports from the Canadian Maritime Provinces, just the opposite of March, 1910. In the United States pressure was high in the South and West in all of the months considered, thus indicating a preponderance of anticyclonic movement from the Northwest and West and naturally a deficient rainfall. The pressure type associated with deficient precipitation in the United States is conceived to be therefore low in the North and high in the South, or, in terms of anticyclonic movement, a drift to the southeast west of the Great Lakes. Concurrently therewith cyclones appear to move along the northern circuit but without pronounced ridges of high pressure separating them, and thus pressure on the mean of the month is below the normal. The precipitation under such conditions is generally light.

For the current month pressure was in excess of the normal in the region of the Great Lakes and thence eastward to the Atlantic. (See inset on Chart I of this REVIEW and also the paths of anticyclones on that chart.) The abnormality of temperature is shown on Chart III and that of precipitation by the inset on Chart IV. On the latter it may be seen that several small areas of precipitation above the normal appear, in some of which the contrast between rather closely situated stations, as for example, Washington and Baltimore, is pronounced. This is due in that instance, and perhaps in others, to the occurrence of a single intense rainfall at the beginning of the drought, a feature that has been previously noted; in other words, drought is at times ushered in by an exceptionally heavy fall of rain.

RECORDS OF TORNADOES IN TENNESSEE, 1808-1921.

By ROSCOE NUNN, Meteorologist.

[Weather Bureau, Nashville, Tenn., September 2, 1922.]

A paper on the subject of tornadoes, especially those that have occurred in Tennessee, was given before the Tennessee Academy of Science, November 25, 1921. For that paper the records of tornadoes in Tennessee for the period 1889–1921, only, were used, the data for these years being considered as more complete than for the earlier years. But it may be well to include all available records in the present discussion, and mention will therefore be made of the data collected and studied by Lieut. John P. Finley, of the Signal Corps, which cover the period 1808–1888.

It should be borne in mind that tornado statistics for the earliest years of record must necessarily be incomplete. Even at the present time a tornado may occur without being recorded. Tornadoes always have narrow paths and frequently the path is only a few miles in length. It is therefore conceivable that even now, when the population is much more dense than it was 100 or even 50, years ago, a tornado might strike a thinly populated area and escape notice, or, at least, fail to be placed on record.

Prior to 1871 the records for Tennessee are very scattering and doubtless incomplete, for Finley was able to report only nine tornadoes for the period 1808–1870; and of these nine there were three in the year 1830. Beginning about 1871, when the old Signal Corps (predecessor of the Weather Bureau) began its meteorological work, tornado records are much more complete, as indicated by Finley's statistics, which show 9 tornadoes for the period 1871–1878 and 23 for the 10-year period of 1879–1888.

An average annual frequency obtained from Finley's data for the period 1871–1888 is slightly greater than the average obtained from the data for the period 1889–1921. If we combine the two periods, making one period of 51 years, with 79 tornadoes, we get an average frequency of 1.5 tornadoes per year in Tennessee, which is probably very nearly correct. This is a low frequency as compared with the frequency in the principal tornado regions; for example, the annual average frequency for Kansas is 8.8. (See article by S. P. Peterson in the MONTHLY WEATHER REVIEW for May, 1922.)

Tornadoes occur more frequently in the spring than any other part of the year. In Tennessee during the last 33 years April has a greater number of tornado dates than any other month, viz., 6; then comes March, with 5, May with 4, January with 2, and February, July, August, September, October, November, and December with 1 each; while June has no tornado accredited to it during these years. On some occasions as many as 4 different tornadoes occurred almost simultaneously, traveling in nearly parallel paths; so that, with a total of 24 different dates for the last 33 years, we have a total of 47 tornadoes.

There is no regularity whatever in the occurrence of tornadoes. There were none in 1896, 1897, and 1898, and only one in 1899, but in 1900 came the very unusual visitation of November 20, when 39 people were killed and much property destroyed, principally at Columbia. There was a remarkable absence of tornadoes in the State during the period 1901–1908; but this was followed by that most memorable tornado year, 1909, with four destructive storms on April 29, killing 60 people in the State, and three storms on October 14, killing 9 people. The years 1910, 1911, and 1912, were free from tornadoes, but in 1913 there were four, all on March 13, causing 21 deaths. The years 1914 and 1918 were without tornadoes in this State, but they were frequent in 1917, 1920, and 1921, though not very destructive. In 1921 the frequency with which they occurred in Maury, Marshall, and Bedford Counties was quite notable.

The geographical distribution of tornadoes in Tennessee is shown in figure 1A. As indicated by the arrows, a large majority of them move toward the northeast. The eastern half of the State, which is elevated and mountainous, has very few tornadoes, and if one occurs its path is quite short.

The Highland Rim of middle Tennessee doubtless has some effect in the way of weakening or breaking up tornadoes that originate in Mississippi and Alabama and move northeastward, but they frequently go over the highlands and move across the Central Basin. They also originate within the Central Basin. No tornado of much consequence has struck Nashville, but the storm of February 12, 1880, was probably a light tornado. It passed over the city about midnight and damaged the Federal Building, according to the report, "moving several blocks of granite and tearing down a gable end."

18004—22——3

Figures 1B and 1C show the paths of the most noteworthy tornadoes during the period 1900 to 1921, inclusive. In figure 1B one of the longest tornado paths of record anywhere is shown. This tornado entered the State in Shelby County about 7:30 p. m. of April 29, 1909, and moved northeastward to Scott County and bringing the total number of deaths in the State up to 60 on that day. April 29, 1909, therefore, marks the most disastrous tornado date in Tennessee's history. In the same year, on October 14, three tornadoes occurred, killing nine people. These October storms moved from northwest to southeast. (See Fig. 1B.)

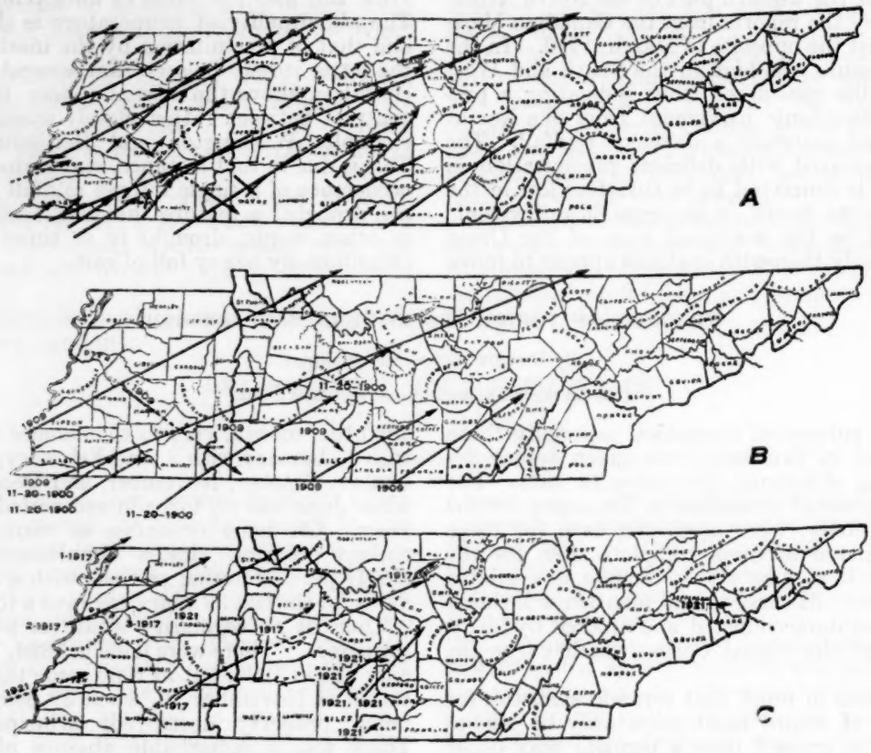


FIG. 1A.—Paths of all tornadoes recorded in Tennessee, 1880-1921, inclusive; 47 tornadoes in 33 years.
FIG. 1B.—Paths of tornadoes of Nov. 20, 1900 (one of the principal tornado dates in Tennessee records), and paths of tornadoes, year 1909. These were the most destructive on record in Tennessee. Those having a northeasterly direction occurred on Apr. 29; those moving from the northwest occurred on Oct. 14.
FIG. 1C.—Paths of tornadoes, years 1917 and 1921. The series (marked 1-1917, 2-1917, tc.) occurred on May 27; Marshall County had four tornadoes within two months, one on Mar. 24, 1921, two on Apr. 16, and one on May 10.

apparently died out soon after entering the adjoining county in Kentucky about 2 a. m. of April 30, making a path at least 320 miles long. The width of the path varied from a few hundred yards to about 1 mile. The tornado did not strike any large towns, but killed 23 people and destroyed property to the amount of about $425,000. Three other nearly parallel storms, with much shorter tracks, occurred the same day, between 2 p. m. and midnight, all of which were destructive,

As stated in the beginning, tornado frequency in Tennessee is comparitively low, and only a small percentage of those that occur assume disastrous proportions. Lightning causes many times more damage and kills many more people than tornadoes, taking the United States as a whole, and the same rule probably holds true in Tennessee, though exact statistics are not available.

THE HEAVY RAINFALL OF SEPTEMBER 2, 1922, AT WASHINGTON, D. C.

By ALFRED J. HENRY.

[Weather Bureau, Washington, September, 1922.]

Rain which began at 1:55 a. m., September 2, 1922, was not continuously heavy, but heavy downpours were interspersed at three different points in the duration of the storm. The first began at 3:45 a. m. and continued for 15 minutes, with a total fall of 0.22 inch; at 4:10 a. m. 0.10 inch fell in five minutes; then the rain slackened until 5:25 a. m., when the very heavy fall of the storm began, continuing until about 7:15 a. m., the total fall in this time being 3.49 inches. A third and last excessive fall occurred at 8:30 a. m., lasting about 15 minutes. Rain ceased at 10:25 a. m.

A noteworthy characteristic of the storm was the absence of local surface wind movement. The direction of the wind before and during the first part of the storm was southeast, with occasional backing to the northeast. During the heavy downpours it was in an easterly quarter and the force was very light; the total wind movement from midnight of September 1 to 6 a. m. of September 2 was but 30 miles, or an average of 5 miles per hour. During the succeeding six hours the wind freshened to an average of 7 miles per hour.

It is generally held that the quantity of rain that falls in very heavy local storms is due to the importation of moist air from outside of the immediate center of heavy precipitation. The cause of the periods of excessive rain interspersed throughout the course of the storm can not be determined from surface conditions. The dewpoint and relative humidity at the 8 p. m. observation of September 1 were 65° and 79 per cent, respectively, and at 8 a. m. September 2, 70° and 100 per cent, respectively; it may then be assumed that the moisture content of the air was high. The barometric conditions were rather stable, with a gradient for southeast to south winds. It is possible, however, that there may have been a local depression in the pressure field over the District of Columbia, as indicated by the loop in the isobar of 30.10 inches on the morning map of September 2. Otherwise it is difficult to account for the northeast air currents that were registered. Since surface relief can not be invoked to account for the heavy downpours, there remains the inference that more or less vagrant currents of cooler air were probably brought in by northeast winds. These latter, being cooler than the southeast winds, would underrun them and thus cause them to be cooled below the dewpoint.

It is interesting to consider for a moment the tremendous weight of water precipitated over the District of Columbia in this storm. The average of 25 stations as given in the table below is 4.23 inches. East of the Anacostia River there was a small area having a total fall greater than 5 inches. In the neighborhood of the Weather Bureau building there was another and larger area of 5 inches, but in general the fall was between 4 and 5 inches. Taking it as 4 inches, and remembering that 4 inches of rain correspond to 452 tons (2,000 pounds) to the acre, the total water precipitated on a square mile of the city of Washington would be $452 \times 640 = 289{,}200$ short tons, and this number multiplied by, say, 40 as roughly approximating the area affected by the storm in square miles, gives a grand total of 11½ million short tons of water that had to be disposed of on the date in question.

The table below gives the rainfall as measured at 25 different points within the District of Columbia.

TABLE 1.—*Rainfall as measured at 25 different points within the District of Columbia.*[1]

Station No.	Rainfall.	Station No.	Rainfall.
	Inches.		*Inches.*
1	5.63	15	4.92
2	5.00	16	3.69
3	3.68	17	3.37
4	3.75	18	5.00
5	3.88	19	2.40
6	4.38	20	3.95
7	4.62	21	4.42
8	3.95	22	4.10
9	3.87	A	3.65
10	4.58	B	4.19
11	4.00	Weather Bureau	5.16
12	5.00		
13	4.80	Mean	4.23
14	3.75		

[1] Courtesy J. B. Gordon, sanitary engineer, District of Columbia.

Note added September 15.—Since writing the above there has come to my attention an automatic record of an intense rainfall at Pulaski, Va. Through the courtesy of the General Chemical Co. of New York, Mr. E. C. Knobel, in charge plant extension division, a photostat copy of the tipping-bucket-gauge record of the intense rainfall of July 21, 1922, at Pulaski has been received.

The intensity of the rain in this case was great from the very beginning of the storm, and the rain ceased almost as suddenly as it began. The total in one hour was, by tipping bucket, 3.60 inches, and by stick measurement, 3.81 inches.

Pulaski is in the extreme southwestern hilly country of Virginia and is situated on Peak Creek, a tributary of New River. This creek flows in a general east-northeast by west-southwest direction in a valley between Tract Mountain on the northwest and Draper Mountain on the southeast, the latter distant about 2 miles from the village of Pulaski and about 800 feet higher.

Pulaski on the morning of July 21 was in a region of weak pressure gradient and light winds; at the beginning of the rain and for several hours previous the wind had been light northeast; at 8:06 p. m. it shifted to west and 10 minutes later to southeast, from which direction it continued until the end of the rain. The force of the wind was greatest during the early part of the rain, but it did not excees 10 miles per hour at any time.

In 1894 the late Prof. C. Abbe computed the equivalent amount of aqueous vapor in the atmosphere if condensed as rain under certain assumed surface dewpoint temperatures in a column of air of various altitudes. The computation showed that the total amount of moisture in a column of saturated air extending from sea level up to 30,000 feet (5.7 miles) with a surface dewpoint of 80° F. would amount to 2.8 inches; at dewpoint 70° it would be 2.1 inches. The dewpoint at Washington, D. C., at the time of the heavy downpour must have been at least 70°, and since the rainfall was more than double that amount, it might be inferred that the air column over Washington was completely renewed during the prevalence of the rainstorm. The same conditions would apply to Pulaski, Va.

SESSIONS OF THE METEOROLOGICAL SECTION OF THE INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS, ROME, ITALY, MAY 4-9, 1922.

By HERBERT H. KIMBALL.

[Weather Bureau, Washington, July, 1922.]

Meetings were held daily, except Sunday, from May 4 to 9, inclusive, and in addition a joint meeting with Section (D), Terrestrial Magnetism and Electricity, was held on the 5th. Sir Napier Shaw, of England, presided at all the meetings. In the absence of Professor Marvin, the secretary, Doctor Kimball, the delegate from the United States, was asked to serve as secretary pro tempore, and Professors Platania and Eredia, delegates from Italy, were designated assistant secretaries.

In all, 33 delegates were in attendance, representing most of the allied nations, and a few that were neutral, during the World War.

The Section particularly concerned itself with two subjects: (1) Its relations with the International Meteorological Committee, and the International Conference of Directors of Meteorological and Magnetic Institutions, and (2) plans for international cooperation on certain research problems.

With reference to (1) it was agreed that all questions of a routine or an administrative character should be referred for consideration to the International Meteorological Committee, the Section confining its activities to scientific problems the solution of which calls for international cooperation. Furthermore, the International Conference of Directors of Meteorological and Magnetic Institutions, which is to meet in Holland in 1923, was asked to consider if there is a duplication of work in its functions and those of the Union.

With reference to (2), resolutions were adopted providing for certain researches, the procedure for the carrying out of which will be outlined later by the Bureau[1] of the Section.

These researches include the following:

I. The determination of the quantities of hydrogen in the atmosphere in different localities and at different heights.

II. The exploration of the upper atmosphere by means of sounding balloons in regions which are of especial importance from the viewpoint of the general circulation of the atmosphere, which regions have not at the present time an effective meteorological organization for carrying on work of this kind.

III. The exploration of the stratosphere by means of pilot balloons, in the regions of permanent high pressure, in the desert regions of the great continents, and over the Equator.

IV. The examination of the dust in the atmosphere in different countries.

V. A report on our knowledge of the radiation from the sun, the soil, the sea, and the air, from the viewpoint of the general circulation of the atmosphere.

VI. A report from the several countries affiliated with the Union on the methods they employ in weather forecasting.

VII. A study of the details of convection in the atmosphere.

VIII. Commendation of the work on solar radiation carried on by the Astronomical Observatory of Naples, and by the Astrophysical Observatory of the Smithsonian Institution of Washington.

The budget of the Section was approved as follows:

	Francs.
General expenses	5,000
Exploration of the air by sounding balloons	20,000
Exploration of the stratosphere by pilot balloons	5,000
Examination of the dust of the atmosphere	2,500
Total	32,500
Allotment	32,542

The Bureau of the Section is constituted as follows:

President, Sir Napier Shaw, England.
Vice president, Prof. C. F. Marvin, United States.
Vice president, Colonel Delcambre, France.
Secretary, Prof. F. Eredia, Italy.

The Executive Committee consists of the Bureau and the following:

Dr. G. C. Simpson, England.
M. Alex. Wallen, Sweden.
Prof. F. Gamba, Italy.

[1] The officers of the Section considered collectively are known as the Bureau.

NOTES, ABSTRACTS, AND REVIEWS.

DR. HELLMANN RETIRES.

Prof. Dr. G. Hellman announces his retirement from the directorship of the Prussian Meteorological Institute on October 1, 1922. Upon the same date he became professor emeritus, instead of ordinary professor, in the University of Berlin.

In his notice of retirement Dr. Hellmann expresses his grateful thanks to his many colleagues both at home and abroad for favors received during his long period of service. He was connected with the Meteorological Institute for 43 years.

NEW NORWEGIAN WEATHER MAPS.

The Bergen Division of the Norwegian Meteorological Institute began on January 1, 1922, the issue of twice-daily morning and evening weather maps prepared in accordance with the theoretical views expressed in various publications.[1]

The size of the charts is 37 by 51½ cm. and they cover the area between the Mediterranean on the south and about 77° north latitude and longitude 50° east to 50° west. The observational data are those received for the daily forecast service. The direction and force of the wind and the temperature are shown graphically in their respective geographic positions on the chart and isobars are drawn. Up to this point the maps are of the usual type of synoptic charts; the distinctly new feature of the maps is the drawing in of the warm front, the cold front, and the occluded fronts which have been found to exist by the analysis of the observational material. A short text is affixed which gives information not elsewhere presented concerning the basis for drawing the respective fronts.

The authors say:

> The maps are destined to illustrate the importance of discontinuities and they are often purposely drawn with a somewhat exaggerated distinctness of these traits.
>
> The scanty data from many parts of Europe often render the analysis impossible, or at least fairly hypothetical and we must make strong reservations as to the correctness of many details regarding the constructed fronts.
>
> The scientific preparation of the maps has been made by Meteorologists E. Calwagen, J. Eythorsson, J. Schinze and F. Spinnagr.

—*A. J. H.*

[1] *Geofisiske Publikationer*, Kristiania, "On the structure of moving cyclones"; "Meteorological conditions for the formation of rain"; "Life cycle of cyclones and the polar front theory of atmospheric circulation". J. Bjerknes and H. Solberg.

CLIMATOLOGICAL ATLAS OF NORWAY.[1]

A new edition of Mohn's *Atlas of the Climate of Norway* has just been published. The atlas contains 60 maps and treats all the meteorological elements except precipitation. The bases of these maps are the tables of climate calculated from the observations of the Norwegian Meteorological Institute, gathered and elaborated during the years 1847-1913. The observations were organized on the international model after the first International Meteorological Congress, at Vienna in 1873. The execution and elaboration of observations are described in the "Jahrbuch des Norwegischen Meteorologischen Instituts."

Plates 1-20. Temperature of the air.
21-28. Humidity of the air.
29-40. Pressure and wind.
41-44. Force of the wind.
45-48. Days of tempests and most frequent direction.
49-52. Cloudiness.
53-56. Days of cloud.
57-60. Days of thunderstorms.

The authors have made a very careful and comprehensive study and the material is well planned.

One interesting feature is the maps showing average monthly temperatures. The contrast between the summer and winter months is brought out very clearly by the steepness of the temperature gradient between the marine climate of the coast and the continental mountain climate. There are very few isotherms for the summer months, but a considerable number of them in the winter months. The lines of equal annual range are also much crowded between coast and interior.

The water-vapor tension remains about the same for January, July, and October, while April shows a slight decrease. The relative humidity is higher in summer than in winter. The pressure gradients follow closely those of temperature for each month.—*G. F. H.*

BOLETIM METEOROLOGICO.[1]

The Brazilian weather service (Dr. Sampaio Ferraz, director) has just issued a bulletin written in Portuguese containing a large amount of valuable meteorological data from 1881 to 1914. This bulletin, together with the records of the Argentine service, now places within reach of climatologists reliable observations covering fairly long periods of time for a large part of South America. The Brazilian publication contains the records of the observatory at Rio de Janeiro in great detail, and those of 59 other regular stations throughout the country, and 32 rainfall stations in lesser detail. No detailed maps are attempted, as in the publication of the Argentine service, for it must be remembered that there are large stretches of the interior of Brazil which are scarcely known, and that the 91 stations are so scattered as to make the construction of a correlated map extremely difficult. The three maps of the distribution of rainfall in 1914, which are included, show this difficulty in their patchy character and in the large area still blank. One of the maps shows the distribution throughout the year, while in the other two, the year is divided into two "semesters" of six months each, from January to June, and July to December. The reason for this division of the year is not given.

[1] H. Mohn, Atlas de Climat de Norwége, Nouvelle edition par Aage Grearud et Kristen Irgens. Geofisiske Plubl. Vol. 2, No. 7, Kristiania, 1922.

[1] Anno de 1914, 4to, 121 pp., 3 maps, Directoria de Meteorologia, Rio de Janeiro, 1922. Cf. review in MO. WEATHER REV., June, 1922, 50, 309-310.

Some idea of the scope of the observations may be found from the following list of the tables contained in the bulletin:

RECORDS FROM RIO DE JANEIRO, 1914.

1. Daily rainfall (with diagram).
2. Hourly rainfall
3. Hourly mean rainfall by months.
4. Comparison of the monthly rainfall of 1914 with the average for 34 years observation.
5. Monthly rainfall, and rainfall days, 1881-1914.
6. Monthly insolation.
7. Hourly insolation.
8. Variations from hour to hour by months of temperature, vapor tension, relative humidity, and wind velocity.
9. Frequency by months of certain amounts of temperature change from hour to hour, and from day to day.
10. The same for relative humidity.
11. A summary of the last three tables for the year 1914.
12. Correlation of the wind directions with certain other observations.
13. Table of monthly rainfall, evaporation, and insolation for 1914.
14. General table of all observations for 1914.

These tables are followed by the less detailed observations for the same year from 59 regular stations, and by the rainfall data from 32 rainfall stations.—*P. E. J.*

THE GREEN RAY.

By Dr. M. E. MULDER.

Doctor Mulder deserves our thanks for assembling and publishing so many observations and discussions of the "green ray," or "green flash," as the sudden turning to green of the last starlike tip of the sun, as it sets behind a distant, clear, and cloudless horizon, is called—an interesting phenomenon, and very common, especially over water. I myself have seen it many times, both on land and at sea, always as an objective reality, never as a mere after-image.

When the sun sets in a clear sky, its last rays obviously leave the observer in the order of their refrangibility, that is, red first, then the orange, yellow, green and blue. Evidently, therefore, the color of the last tip of the setting sun is green, or even bluish green, for about a second, when the air is exceptionally clean, and red when the lower atmosphere is so laden with dust as to transmit but little light of the shorter wave lengths.

Although an adequate description and complete explanation of the "green ray" can be given in a few lines, Doctor Mulder's book, somewhat evenly divided between English, French, and German, is pleasant reading. It also has the merit of preserving several references to blue and green suns, unusual phenomena for which no generally-accepted explanation has yet been offered.—*W. J. H.*

IS THE ATMOSPHERE WARMED BY CONVECTION FROM THE EARTH'S SURFACE?[1]

By W. SCHMIDT.

[Reprinted from *Science Abstracts*, Section A, § 1512, p. 542.]

By convection is here understood the combined effect of pure thermal convection caused by warming of the lowest layers by contact with a heated surface and also mixing of dynamical origin arising out of the passage of air over the earth's rough surface. Evidence is produced to show that when the latter is present mixing is in general much more effective and the flux of heat greater than when the former alone is active. The direction of the flux of heat depends on whether the actual temperature gradient exceeds or falls short of the adiabatic, and by consideration of the average observed lapse of temperature in different regions, and including in the high layers latent heat carried up by water vapor and liberated when condensation occurs, the author draws the conclusion that, contrary to the usual view, except for a comparatively narrow equatorial zone, the average flux of heat by convection over most of the globe is *toward* the earth's surface, which in this respect exercises a cooling action. But the lower atmosphere may be warmed on the average by long-wave radiation emitted by the earth.—*M. A. G.*

[1] *Meteorologische Zeitschrift*, September, 1921, 38, 262-268.

SUNSPOT IN HIGH LATITUDE.

[Reprinted from *Nature*, London, September 23, 1922, p. 428.]

A small sunspot was noted at Mount Wilson, Calif., on June 24, 1922, in latitude 31° N., longitude 8° E. No spot has been seen in such a high latitude since December, 1919, and it is considered to be the first spot of the new cycle. It will be remembered that the equatorial spots of the expiring cycle continue for a year or more after the commencement of the new one, so that the actual minimum may not be reached till next year. The above spot was of negative polarity, whereas most of the single northern spots in the expiring cycle were positive. This is a further argument, though not a decisive one, for the spot belonging to the new cycle.

BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Meteorologist in Charge of Library.

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Apia. Samoa Observatorium.
Resultate der meteorologischen Beobachtungen am Samoa-Observatorium von 1916 bis 1919. p. 218–220. 30 cm. (Repr. Meteorologische Zeitschrift. H. 7. 1922.)

Austria. Zentralanstalt für Meteorologie und Geodynamik.
Allgemeiner Bericht und Chronik der in den Jahren 1916–1921 in Österreich beobachteten Erdbeben. Mit einem Nachtrag über die in Niederösterreich in den Jahren 1914 und 1915 beobachteten Erdbeben. Wien. 1922. 40 p. chart. 23 cm. (Amtliche Veröffentlichung. No. 13.)

Bemporad, A.
Nuova formulazione della teoria dell' assorbimento selettivo dell' atmosfera e nuove esperienze in proposito. Napoli. 1917. 7 p. 24 cm. (Extr.: Rend. della R. accad. delle scienze fisiche e matematiche di Napoli. Ser. 3a. v. 23. 1917.) (R. Osserv. astron. di Capodimonte. Contributi astronomici. No. 15.)

Bemporad, A., *& others.*
Osservazioni pireliometriche eseguite a Capodimonte nell'anno 1914. Napoli. 1921. 61 p. illus. 34 cm. (Memorie del R. Osserv. di Capodimonte in Napoli. No. 6.)

Briggs, Glen.
Vegetable growing in Guam. Washington. 1922. ii, 60 p. plates. 23½ cm. (Guam agric. exper. sta. Bulletin no. 2.) ["Climate." p. 3.]

Bunge, Bernh.
Der Registrierapparat für Sondier-Gummiballone nach Assmann und Anleitung zur Prüfung desselben. Berlin. n. d. 4 p. plate. 27 cm.

Campo, Gabriel.
Relació entre els halos i les pluges ciclòniques a Catalunya. Barcelona. 1922. 8 p. 22 cm. (Servei meteorològic de Catalunya. Notes d'estudi. No. 6.)

Chambers, Charles.
Studies in the dynamics of the earth's atmosphere. London. 1920. 28 p. illus. port. 25 cm.

Crunden, Allen B.
Sleet storms. p. 14–22. 25½ cm. [Excerpt from Bell telephone quarterly. v. 1. no. 2. July, 1922.]

Cundall, Leonard B.
Human geography of the British Isles. London. 1920. v, 359 p. illus. 19 cm. [Chapter 1. Climate and weather. p. 1–56.]

Durward, J.
Diurnal variation of temperature as affected by wind velocity and cloudiness. A discussion of observations on the Eiffel tower. London. 1922. p. 84–91. illus. 25 cm. (Great Britain. Metl. office. Professional notes no. 30.)

Eredia, Filippo.
Sugli strumenti adoperati per la misura delle precipitazioni atmosferiche. Roma. 1922. 24 p. illus. 25½ cm. (Annali del Consiglio superiore delle acque. v. 4, fasc. 1, 1922.)

Estalella, Josep.
Les denominacions dels vents a la costa de Llevant. Barcelona. 1922. 4 p. illus. 22 cm. (Servei meteorològic de Catalunya. Notes d'estudi. No. 7.)

Febrer, Joaquim.
Pluges a Catalunya durant l'hivern de 1921–1922. Barcelona. 1922. 8 p. illus. 22 cm. (Servei meteorològic de Catalunya. Notes d'estudi. No. 8.)

Fisher, Willard J.
Low sun phenomena. Cambridge. 1922. p. 38–45. 30 cm. (Annals astronomical observatory. Harvard college. v. 86. pt. 1.)

Fontseré, Eduard.
Distribució altimètrica de les humitats mitjanes des del port de Barcelona a la muntanya. Barcelona. 1921. 29 p. illus. 26 cm. (Extr.: Miscellània prat de la riba.)

Great Britain. Hydrographic office.
Monthly meteorological charts for western Europe. With bibliography, and periods of observation, meteorological tables, and explanation of the charts. [London.] 1921. 63 p. charts. 58 cm.

Gregg, Willis Ray.
Standard atmosphere. Washington. 1922. 11 p. figs. 29½ cm. (National advisory committee for aeronautics. Report no. 147.)

Hubert, Henry.
Nouvelles recherches sur les grains orageux en Afrique occidentale. 4 p. 25 cm. (Acad. des sci., Comptes rendus. Paris. t. 173. 1921.)

International meteorological committee.
Report of proceedings of the fourth meeting of the International commission for weather telegraphy, held at the air ministry, London September 8th–10th, 1921. London. 1922. 35 p. 24½ cm. (Appendix VI. Report 11th ordinary meeting of Internat. metl. comm.)

Report of the eleventh ordinary meeting, London, 1921; and of meetings of the commissions for weather telegraphy, maritime meteorology, aerial navigation, réseau mondial, and polar meteorology . . . London. 1922. 128 p. 24½ cm.

International union of geodesy and geophysics. Section of meteorology.
Première assemblée générale. Rome, mai, 1922. Procès-verbaux des séances. Rome. 1922. 32 p. 25 cm.

Johnson, N. K., & Sen, S. N.
Comparison of the anemometer records for Shoeburyness and the Maplin lighthouse. London. 1922. p. 70–76. illus. 24½ cm. (Great Britain. Meteorological office. Professional notes no. 28.)

Kincer, J. B.
Precipitation and humidity. Washington. 1922. 48 p. maps. 48 cm. (U. S. Dept. agriculture. Atlas of American agriculture. pt. 2. Climate. Sec. A.)

Lasserre, A.
Les territoires du sud de l'Algérie. Exposé de leur situation . . . (Extrait) Aperçu météorologique. Alger. 1922. 35 p. plates. 24½ cm.

Lyon, T. Lyttleton, & Bizzell, James A.
Lysimeter experiments. II. Records for tanks 13 to 16 during the years 1913 to 1917, inclusive. Ithaca. 1921. p. 51–93. 23 cm. (Cornell univ. agric. exper. sta. Memoir 41. July, 1921.)

Mast, C. O.
Truth about lightning and lightning rods. Dayton. [1922.] 1 sheet. 39 cm.

Okada, T.
On the eye of the storm. n. p. n. d. 10 p. plate. 26½ cm. (Repr.: Memoirs imp. marine obs., Kobe. v. 1, no. 1, 1922.)

Palmer, George T.
Ventilation, weather, and the common cold. A study of the prevalence of respiratory affections among school children and their association with school ventilation and the seasonal changes in weather. 39 p. charts. 25½ cm. (Journ. of lab. & clin. med. v. 6, nos. 11–12; v. 7, no. 1, Aug.–Oct., 1921.)

Pettersson, Otto.
Om månens inflytande på klimat och väderlek. [Stockholm. 1916.] p. 103–137. illus. 23½ cm. (Ymer. Svenska sällskapet för antropologi och geografi. H. 2. 1916.)

Quayle, E. T.
Local rain producing influences under human control in South Australia. Melbourne. 1922. p. 89–104. map. 24½ cm. (Repr.: Proceedings Royal society, Victoria. (new series) v. 34.)

Réthly, Antal.
Adatok a kossava természetrajzához. Budapest. 1922. 9 p. 24½ cm. (Repr.: Földrajzi Közlemények. v. 50. pt. 1–5. 1922.)

Riel, P. M. van.
Accuracy of barometer readings on board of moving ships. Utrecht. 1921. 8 p. 24½ cm. (K. Ned. met. inst. No. 102. Meded. en verh. 25.)

Rosa, J. T., jr.
Investigations on the hardening process in vegetable plants. Columbia. 1921. 97 p. figs. illus. 23 cm. (Univ. Mo. College of agric. Agric. exper. sta. Research bulletin 48.)

Schoute, C.
Ein Registriertheodolit für Pilotballone. Utrecht. 1921. 41 p. illus. 24½ cm. (K. Ned. met. inst. No. 102. Meded. en verh. 26.) [Text in German and English.]

Seismos-Gesellschaft.
Erforschung von Gebirgsschichten und nutzbaren Lagerstätten nach dem seismischen Verfahren. Hannover. 1922. 14 p. illus. 28½ cm. (Mitteilungen der Seismos-Gesellschaft. I.)

Sherman, V. L.
Weather profits in building. p. 26–27. maps. 30½ cm. [Extr. National builder. v. 65, no. 8, Aug., 1922.]

Sifontes, Ernesto.
Las lluvias en Ciudad Bolívar. trim. 1–2. Bolívar. 1922. 2 sheets. 66½ cm.

Sweden. Meteorologiska centralanstalt.
Meteorologiska iakttagelser. Bihang 60. 1918. Termosynkroner och termoisokroner på den Skandinaviska halvön. (Thermosynchrones et thermoisochrones dans la péninsule Scandinave.) Stockholm. 1922. 39 p. plates. 31½ cm.

Vercelli, Francesco.
Sulla previsione dei termini di correzione nelle maree. Roma. 1922. 24 p. illus. plates. 23½ cm. (Rivista marittima del Feb., 1922.)

[Walford, Edwin A.]
Shepherd of Banbury's rules to judge of changes of the weather, and some rhymes. [Banbury. 1905.] unp. 10½ x 17 cm.
Shepherd of Banbury's weather rules, and some rhymes and sayings. [Banbury. 1920.] unp. 10½ x 17 cm.

Wallén, Axel.
Conférence météorologique à Kristiania. p. 122–126. 25 cm. (Notiser.) (Geografiska annaler. H. 1. 1922.)
Nya forskningar över människans och kulturens utveckling i förhållande till klimatet. 1922. 32 p. illus. 24 cm. (Extr.: Ymer. Svenska sällskapet för antrop. och geogr. H. 1. 1922.)
Vattenstånds förutsägelser. Granskning av 1921 års resultat och prognoser för år 1922. Stockholm. 1922. 17 p. figs. 20½ cm. (Teknisk tidskrift. Häft. 16, 1922.)

Wigand, Albert.
Aerologische und luftelektrische Flüge und ihre Bedeutung für die Luftfahrt. [München.] 1921. 18 p. illus. 32 cm. (Berichte und Abhandlungen der wissenschaftlichen Gesellschaft für Luftfahrt. Beihefte: Zeits. für Flugtechnik und Motorluftschiffahrt. H. 4. April, 1921.)

Zierl, Hermann.
Die Hörbarkeit der Explosion von Oppau in Bayern rechts des Rheines. 6 p. illus. 33 cm. (Extr.: Deutschen meteorologischen Jahrbuch, Bayern. 1921.) [Bibliography. p. 5–6.]

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. F. TALMAN, Meteorologist in Charge of Library.

The following titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

American philosophical society. Proceedings. Philadelphia. v. 61. no. 2, 1922.
Douglass, A. E. Some topographic and climatic characters in the annual rings of the yellow pines and sequoias of the southwest. p. 117–122.

Annales de physique. Paris. v. 18. Juillet-août 1922.
Mathias, E. Rapport sur l'état actuel de l'électricité atmosphérique. p. 83–170.

Brazil. Directoria de meteorologia. Revista mensal de meteorologia. Rio de Janeiro. v. 1. 1922.
Coussirat de Araujo, L. Instrucções geraes para a reorganização do Serviço meteorologico de Minas Geraes. p. 22–36. (Abril.) p. 41–65. (Maio.)
Silva, Moacir. Indicador meteorologico Brasileiro. Localidades em que ha (ou houve) observações meteorologicas. p. 48–53. (Abril.) p. 76–83. (Maio.) [A gazetteer of present and former meteorological stations in Brazil, with references to published observations, etc.]
Silva, Herminio. As sondagens atmospphericas—processo do balão piloto. p. 3–11. (Maio.)
Sousa, Francisco de. A distribuição de previsão do tempo no estado de S. Paulo. p. 33–40. (Maio.)

Ciel et terre. Bruxelles. 38 année. Août, 1922.
Navarro-Neumann, Manuel Maria S. Le sismographe inverti "Berchmans" de la station sismologique de Cartuja (Grenade). p. 277–281.

France. Académie des sciences. Comptes rendus. Paris. t. 175 9 Oct. 1922.
Soreau, Rodolphe. Sur les lois de variation des caractéristiques de l'air standard avec l'altitude. p. 568–570.

Géographie. Paris. t. 38. Juillet-août 1922.
Rouch, J. Le vent en altitude à Saint-Nazaire. p. 197–200.

Hemel en Dampkring. Den Haag. 20. Jaarg. October, 1922.
Pinkhof, M. Overzicht van de halo-waarnemingen te Amsterdam in 1920 en 1921. p. 193–198.

India. Meteorological department. Memoirs. Calcutta. v. 23. 1922.
Harrison, E. P. The effects of oscillations and of "lag" on the readings of the Kew pattern barometer. (pt. 4.)
Harrison, E. P. On cleaning and refilling various types of barometer, together with a description of several usual patterns. (pt. 5.)

Meteorological magazine. London. v. 57. Sept., 1922.
Brooks, C. E. P. A period of warm winters in Europe. p. 203–205.

Nature. London. v. 110. 1922.
Carpenter, G. D. Hale, & Brunt, D. Waterspouts. p. 414–415. (Sept. 23.)
Brodetsky, S. Motorless or wind flight. p. 483–485. (Oct. 7.)
Mallock, A. Dampier's "Discourse of the winds" and the distribution of wind on the earth's surface. p. 478–480. (Oct. 7.)
Lodge, *Sir* Oliver. One possible cause for atmospheric electric phenomena. A query. p. 512. (Oct. 14.)
Porter, Alfred W. The green ray at sunset and sunrise. p. 513. (Oct. 14.)
Walker, Gilbert T. Periodicities. p. 511–512. (Oct. 14.)

Netherlands. Meteorologisch instituut. Mededeelingen en verhandelingen. Utrecht. no. 26. 1921.
Schoute, C. A recording theodolite for pilot balloons. [German and English text.] p. 3–41.

Physical review. Lancaster, Pa. v. 20. August, 1922.
Downey, K. Melvina. The variation of the residual ionization in air with pressure, for a range of 57 atmospheres. p. 186–193.
Erikson, Henry A. On the nature of the negative and positive ions in air, oxygen and nitrogen. p. 117–126.

Physico-mathematical society of Japan. Proceedings. Tôkyô. v. 4. September, 1922.
Terada, Torahiko. On periodic fluctuations of convection currents—with a hint on the origin of sun-spots cycle. p. 162–169.

Scientific American. New York. v. 127. November, 1922.
Beating lightning at its own favorite game. p. 329. [Describes method of protecting balloons and airships from lightning.]
Individual atmospheres to order. How push buttons control the ventilating and heating system at each seat in the recently completed London county council building. p. 328–329.

Seismological society of America. Bulletin. Stanford University. v. 12. March, 1922.
Hunt, Sumner. Building for earthquake resistance. p. 12–18.
Navarro-Neumann, Manuel Maria S. The Berchmans seismograph. p. 24–27.
Palmer, Andrew H. California earthquakes during 1921. p. 19–23.
Townley, Sidney D. John Casper Branner. p. 1–11. [Obituary.]

Sociedad científica "Antonio Alzate." Memorias y revista. México. Tomo 41. Julio, 1922.
López, Elpidio. Nueva nota sobre los nortes del Golfo. p. 5–15.

Società sismologica italiana. Bollettino. Modena. v. 23. no. 4-5-6.
Agamennone, Giovanni. I fenomeni sismici al Vesuvio dal 1892 al 1906. p. 192–253.
De Fiore, O. Le registrazioni sismiche ottenute all' Istituto vulcanologico a Napoli nel 1914 I–VI. p. 254–262.
Grablovitz, Giulio. Sul sospettato bradisisma appenninico 1900–1908. p. 147–191.
Grablovitz, Giulio. Sulle replichi nei periodi sismici. p. 263–276.

SOLAR OBSERVATIONS.

SOLAR AND SKY RADIATION MEASUREMENTS DURING SEPTEMBER, 1922.

By HERBERT H. KIMBALL, in Charge, Solar Radiation Investigations.

For a description of instruments and exposures, and an account of the method of obtaining and reducing the measurements, the reader is referred to this REVIEW for April, 1920, 48:225.

From Table 1 it is seen that direct solar radiation intensities averaged slightly below the normal for September at Washington and Madison, and very close to normal at Lincoln.

Table 2 shows that the total solar and sky radiation received on a horizontal surface averaged above the September normal at both Washington and Madison.

Skylight-polarization measurements made on 13 days at Washington give a mean of 57 per cent, with a maximum of 65 per cent on the 25th. At Madison, measurements made on 10 days give a mean of 64 per cent, with a maximum of 74 per cent on the 26th. These are average polarization values for September at the respective stations.

TABLE 1.—*Solar radiation intensities during September, 1922.*

[Gram-calories per minute per square centimeter of normal surface.]

Washington, D. C.

Date.	Sun's zenith distance.										
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th meridian time.	Air mass.									Local mean solar time.
		A. M.						P. M.			
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Sept. 6	16.79	.....	.....	0.75	0.91	.....	0.91	0.81	0.67	0.57	17.37
7	17.37	.....	.....	0.49	0.71	0.97	.....	.....	.....	.....	17.37
13	9.83	.....	0.70	0.86	1.07	1.31	1.04	0.81	0.64	0.51	9.14
14	13.13	.....	0.72	0.88	1.07	1.30	1.04	0.83	0.72	0.62	17.37
15	17.37	.....	.....	.....	.....	1.30	1.04	0.83	0.68	.....	19.23
16	13.61	.....	0.30	0.42	0.56	.....	.....	.....	.....	.....	10.59
18	7.87	.....	0.78	0.90	1.07	1.26	.....	.....	.....	.....	8.48
23	9.83	.....	.....	0.53	0.69	0.90	.....	.....	.....	.....	12.24
25	7.04	.....	0.96	1.05	1.26	1.50	1.26	1.07	0.95	.....	6.27
26	5.56	.....	0.83	0.97	1.13	1.32	1.09	.....	.....	.....	6.27
27	8.48	.....	.....	.....	.....	1.17	0.98	0.80	0.68	.....	9.83
28	10.59	.....	.....	.....	0.57	1.09	0.81	0.59	.....	.....	9.14
30	10.97	.....	.....	.....	0.80	.....	.....	.....	.....	.....	12.68
Means	.....	.....	**0.69**	**0.78**	**0.91**	**1.25**	**1.02**	**0.82**	**0.72**	**0.57**	.....
Departures	.....	.....	**−0.04**	**−0.09**	**−0.14**	**−0.06**	**−0.03**	**−0.04**	**−0.01**	**−0.09**	.....

Madison, Wis.

Sept. 6	18.59	.....	.....	.....	1.03	.....	.....	.....	.....	.....	15.65
11	7.29	.....	1.01	.....	1.29	.....	1.27	.....	.....	.....	7.87
22	9.83	.....	0.74	0.90	1.10	1.33	1.10	0.82	.....	.....	11.81
23	12.68	.....	0.78	0.95	1.10	.....	.....	.....	.....	.....	11.81
25	6.76	.....	1.05	1.15	.....	.....	.....	.....	.....	.....	7.29
26	7.29	.....	0.97	1.07	1.26	.....	.....	.....	.....	.....	6.76
27	6.76	.....	.....	.....	.....	.....	1.25	1.07	.....	.....	6.27
28	7.57	.....	.....	.....	1.13	.....	0.97	0.81	.....	.....	6.02
30	9.14	.....	.....	.....	0.78	.....	.....	.....	.....	.....	12.68
Means	.....	.....	**0.91**	**1.02**	**1.10**	**(1.33)**	**1.15**	**0.90**	.....	.....	.....
Departures	.....	.....	**−0.01**	**±0.00**	**−0.06**	**−0.05**	**−0.01**	**−0.11**	.....	.....	.....

Lincoln, Nebr.

Sept. 1	12.68	.....	0.74	0.93	1.10	1.30	.....	.....	.....	.....	10.97
5	14.10	0.78	0.89	1.04	1.20	1.39	.....	.....	.....	.....	11.38
6	12.68	.....	.....	.....	1.14	.....	.....	.....	.....	.....	12.24
7	13.61	.....	0.86	1.03	.....	.....	1.03	.....	.....	.....	12.24
12	7.57	.....	0.85	1.02	1.22	1.45	.....	0.97	0.85	0.66	7.57
13	7.57	0.66	0.88	.....	.....	.....	.....	.....	.....	.....	7.57
20	5.36	.....	.....	.....	.....	.....	1.21	1.05	0.90	0.78	7.57
21	8.48	.....	0.89	1.02	1.18	1.37	1.18	1.00	0.86	0.73	9.47
22	9.14	.....	0.82	1.01	1.16	1.46	1.20	0.99	.....	0.68	9.47
23	8.18	.....	0.86	0.99	1.19	1.40	1.06	0.85	0.69	.....	9.14
25	5.79	.....	.....	.....	.....	1.42	1.16	0.94	0.76	0.65	5.56
26	7.04	.....	0.81	0.94	1.14	1.42	1.16	0.93	0.75	.....	5.79
28	6.02	.....	.....	.....	0.94	.....	.....	.....	.....	.....	8.81
Means	.....	**(0.72)**	**0.84**	**1.00**	**1.14**	**1.40**	**1.14**	**0.96**	**0.80**	**0.70**	.....
Departures	.....	**−0.03**	**−0.01**	**±0.00**	**−0.05**	**+0.01**	**−0.01**	**−0.01**	**−0.02**	**−0.02**	.....

* Extrapolated.

TABLE 2.—*Solar and sky radiation received on a horizontal surface.*

Week beginning.	Average daily radiation.			Average daily departure for the week.			Excess or deficiency since first of year.		
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Sept. 3	379	412	.....	−19	+32	.....	−4,010	−1,917	.....
10	421	325	.....	+38	−30	.....	−3,741	−2,128	.....
17	331	321	.....	−36	−9	.....	−3,935	−2,192	.....
24	422	384	.....	+72	+77	.....	−3,488	−1,653	.....

MEASUREMENTS OF THE SOLAR CONSTANT OF RADIATION AT CALAMA, CHILE, JUNE AND JULY, 1922.

By C. G. ABBOT, Assistant Secretary.

[Smithsonian Institution, Washington, October 31, 1922.]

In continuation of preceding publications, the following table contains the results for the solar constant of radiation obtained at Montezuma, near Calama, Chile, in June and July, 1922. The values of ρ/ρ sc. are given at air mass 2, or if not the air mass is stated. The reader is referred for further statements regarding the arrangement and meaning of the table to the REVIEW for February, August, and September, 1919.

Date.	Solar constant.	Method.	Grade	Transmission coefficient at 0.5 micron.	Humidity.			Remarks.
					ρ/ρ sc.	V. P.	Relative humidity.	
1922.								
P. M.	*cal.*					*cm.*	*Per cent.*	
June 2	1.906	$M_{3\text{-}5}$	S.	0.878	[1] 0.572	0.24	16	Small cumuli in east.
	1.903	$M_{3\text{-}12}$						
	1.905	W. M.						
June 3	1.924	$M_{1\text{-}56}$	S.	.883	[2] .604	.28	18	Cumuli in east.
	1.915	$M_{1\text{-}66}$						
	1.919	W. M.						
June 7	1.876	$M_{2\text{-}56}$	S−	.884	.643	.19	11	Cloudless.
	1.888	$M_{1\text{-}99}$						
	1.903	$M_{1\text{-}74}$						
	1.889	W. M.						
June 14	1.905	$M_{2\text{-}78}$	S−	.889	[3] .775	.15	11	Do.
June 15	1.934	E_9	E.	.884	.847	.07	33	Do.
	1.898	M_2						
	1.923	$M_{2\text{-}5}$						
	1.922	W. M.						
A. M.								
June 16	1.939	$M_{1\text{-}75}$	S−	.886	[4] .886	.04	23	Do.
	1.924	$M_{1\text{-}66}$						
	1.879	$M_{1\text{-}42}$						
	1.931	W. M.						
P. M.								
June 19	1.890	$M_{2\text{-}5}$	S−	.870	.533	.43	28	Cumuli scattered about sky.
	1.889	$M_{2\text{-}60}$						
	1.889	W. M.						
A. M.								
June 25	1.900	$M_{2\text{-}5}$	S−	.884	.694	.17	16	Cumuli in south and west.
	1.934	$M_{2\text{-}9}$						
	1.923	W. M.						
P. M.								
June 29	1.890	$M_{2\text{-}5}$	S−	.889	.762	.15	8	Cloudless.
	1.901	$M_{2\text{-}9}$						
	1.897	W. M.						
June 30	1.918	$M_{2\text{-}5}$	S−	.890	.804	.07	3	Do.
	1.939	$M_{2\text{-}81}$						
	1.947	$M_{1\text{-}81}$						
	1.938	W. M.						
July 1	1.898	M_2	S−	.886	.744	.08	3	Do.
	1.920	$M_{1\text{-}5}$						
	1.913	W. M.						
July 12	1.925	$M_{1\text{-}5}$	S−	.887	.700	.15	6	Do.
	1.917	M_2						
	1.896	$M_{2\text{-}5}$						
	1.916	W. M.						
July 13	1.887	$M_{2\text{-}81}$	S−	.887	[5] .692	.11	5	Do.
	1.888	$M_{2\text{-}27}$						
	1.888	W. M.						
July 14	1.889	$M_{2\text{-}88}$	S−	.888	[6] .724	.10	4	Do.
	1.919	$M_{2\text{-}48}$						
	1.918	$M_{2\text{-}17}$						
	1.913	W. M.						
July 28	1.887	$M_{2\text{-}33}$	S−	0.888	[7] .737	.16	8	Do.
	1.917	$M_{1\text{-}79}$						
	1.907	W. M.						
A. M.								
July 29	1.921	$M_{1\text{-}72}$	S−	.877	[8] .630	.25	17	Do.
	1.924	$M_{1\text{-}55}$						
	1.936	$M_{1\text{-}48}$						
	1.927	W. M.						

[1] Air mass 2.15.
[2] Air mass 1.86.
[3] Air mass 2.78.
[4] Air mass 1.75.
[5] Air mass 2.28.
[6] Air mass 1.90.
[7] Air mass 1.90.
[8] Air mass 1.72.

WEATHER OF NORTH AMERICA AND ADJACENT OCEANS.

NORTH ATLANTIC OCEAN.

By F. A. YOUNG.

The average pressure for the month was not far from the normal at land stations in Newfoundland and on the Atlantic coast of Canada and the United States, as well as in the British Isles, West Indies, and stations in the Caribbean Sea; it was considerably higher than usual in the Azores and also in the Bermudas during the greater part of the month.

The number of days on which fog was observed was not far from the normal over practically the entire ocean, as it was reported on 11 days over the Grand Banks, 9 days off the coast of Canada and New England, and from 7 to 8 days over the eastern end of the steamer lanes.

The number of days with winds of gale force differed considerably over different sections of the ocean, when compared with the normal as shown on the pilot chart, and by far the greater number occurred during the last half of the month.

From the 1st to the 10th moderate weather was the rule over the entire ocean, with the exception of slight disturbances on the 3d and 4th and 7th and 8th over the northern steamer lanes.

From the 10th to the 14th gales prevailed between the 50th meridian and the American coast and from the 11th to the 15th there was an area of low pressure north of the 45th parallel between the 25th meridian and the European coast. Storm logs:

American S. S. *Connes Peak:*

Gale began on the 11th, wind N. by E. Lowest barometer 29.65 inches at 2 p. m. on the 9th, wind NW., 10, in latitude 39° 30′ N., longitude 59° 35′ W. End on the 11th, wind SW. Highest force of wind 10, NW.; shifts N.–NW.–W.–SW.

British S. S. *Comanchee:*

Gale began on the 13th, wind WNW. Lowest barometer 29.01 inches at 8 a. m. on the 13th, wind WNW., 6, in latitude 52° N., longitude 6° 55′ W. End on the 14th, wind N. by W. Highest force of wind 9; steady from WNW.

According to press dispatches two vessels in the mouth of the Panuco River near Tampico, Mexico, foundered during a heavy wind on the 13th. This storm must have been very local in character, as the few reports from craft in that vicinity on the 13th indicated moderate weather.

A very brief report was received from the American S. S. *Kingsway*, stating that on the 13th in latitude 10° 15′ N., longitude 50° W., there was a slight disturbance with heavy, confused sea; barometer 29.80 inches. This was the first vessel report relating to the tropical disturbance that followed a rather unusual track and finally broke up off the coast of Europe on the 28th, causing a great deal of damage in the West Indies and Bermudas.

A most comprehensive account of this storm, covering the period from the 14th to 17th, was received from Dr. Oliver T. Fassig, official in charge at San Juan, Porto Rico. This included reports from the Leeward Islands, made by Mr. A. E. Collens at Antigua and Mr. Geffrey Downing at Barbuda. Doctor Fassig states:

A slight fall in the barometer accompanied by variable winds at Barbados, St. Lucia, and Dominica on September 13 and 14 gave the first intimations of abnormal conditions. About noon on the 14th an unofficial message from Martinique reported a heavy swell from the east and winds varying from N. and NE. to SW., with rumors of a storm approaching from the south.

Frequent barometric observations at Antigua show that the lowest reading was 29.45 inches at 2 a. m. on the 16th, while from 12:30 to 9 a. m. on that date the wind backed from NW. to SW.

Mr. Downing reports from Barbuda as follows:

Between 8 a. m. and 10 p. m. on the 15th the barometer fell from 30 inches to 29.80 inches, the wind rising but steady from NE. By 11 p. m. the barometer began to fall rapidly and the gale to attain hurricane violence. At 1:30 a. m. on the 16th the wind had backed to NW., and the barometer fallen to 28.58 inches, the force of the wind being terrific. At 1:45 a. m. the center of the hurricane reached us, as there was an immediate lull, then a dead calm which lasted until 2:45 a. m. when the wind sprang up from the SE. By 4 a. m. it was blowing as hard as ever, but the barometer was rising, and by 6 a. m. the wind had moderated. One inch of rain fell during the night.

The hurricane apparently caused more damage at Barbuda than at Antigua, and Mr. Downing states that at the former island:

The country looks as though it had been swept by fire, with the fences all down, numerous buildings and trees blown down, while a number of small craft in the lagoon were sunk or blown ashore, although fortunately no lives were lost.

The storm also did a great deal of damage at Anguilla, the highest force of wind and lowest barometer, 29.60 inches, occurring at about 11 a. m. on the 16th. Doctor Fassig states that at 8 p. m. on the 16th a bulletin was distributed giving the center of the storm apparently northeast of St. Thomas, and moving slowly north by west.

On the morning of the 17th the center was probably not far from latitude 21° N. longitude 66° W., although it was impossible to plot its position accurately on account of lack of observations.

The New York Maritime Register of October 4 has the following note:

French S. S. *Mont Rose* arrived at Fort de France, September 17, and reported encountering a cyclone 200 miles off Martinique. The vessel received slight damage. Cargo damaged.

The American S. S. *Paria* at the time of Greenwich mean noon observation on the 17th was in latitude 22° 23′ N, longitude 67° 01′ W, wind ESE., 4, barometer 29.84 inches. Shortly afterwards the gale overtook her, as shown by following storm log:

Gale began on the 17th, wind ESE. Lowest barometer 29.65 inches on the 17th (time not given), wind NE., in latitude 22° 11′ N., longitude 67° 06′ W. End on the 18th, wind SE. Highest force of wind 10; shifts NE. SW.

Charts VIII to XIII show the conditions from September 18 to 23, inclusive.

Continuing in its northwesterly course, the disturbance on the morning of the 18th was central near latitude 24° N, longitude 66° W, and on the 19th, near latitude 26° N, longitude 77° W. It then began to curve toward the east and on the 21st the center was a short distance east of Bermuda. Judging from the few reports received the disturbance seemed to be of moderate intensity from the 18th to the 20th.

By the 21st, however, it had increased tremendously in violence, and Bermuda was visited by the most severe hurricane experienced in years. At the time of the 8 a. m. observation the barometer read 28.72 inches, Wind N., force 8. The lowest barometer was 28.57 inches from 8:40 to 8:55 p. m., highest force of wind 12, WNW. to W.; shifts of wind near time of lowest barometer NE. to WNW.

An interesting account of this storm was received from Lieut. G. E. Harper, R. N., one of the officers of H. M. S. *Valerian*, the vessel being stationed in Bermuda at the time. As shown by this report and a number of

others, a great deal of damage was done on the island, and also to small craft anchored in the harbor. The disturbance continued on its northeasterly course with an increased rate of translation and on the 22d was central near latitude 39° N., longitude 52° W., and on the 23d near latitude 42° N., longitude 47° W. The U. S. battleship *Maryland*, en route from Brazil to New York, ran across the track of this storm at nearly right angles, not far from Bermuda, but missed the center, a wind of force 7, being the highest reported. Storm logs follow:

American S. S. *Cody:*

Gale began on the 23d, wind SSE. Lowest barometer 28.68 inches at 1 p. m. on the 23d, wind calm, in latitude 43° 20′ N., longitude 44° 40′ W. End on the 24th, wind N., highest force of wind 12; shifts 18 points.

British S. S. *Paul Paix:*

Gale began on the 21st, wind S. Lowest barometer 29.42 inches at 8 a. m. on the 23d, wind NE., 8, in latitude 42° 48′ N., longitude 48° 15′ W. End on the 24th, wind NNW. Highest force of wind 8, NE.; shifts SSE.–E.–NE.–N.–NNW.

From the 23d to the 24th the area of low pressure moved rapidly northeastward and on the latter date the center was near latitude 49° N., longitude 29° W. It appeared to be reinforced by some northern disturbance, assuming as it did some of the characteristics of an extra-tropical storm, and there was also a most marked increase in intensity. From the 24th to the 25th the rate of its northeasterly movement had decreased, as on the latter date the center was near latitude 52° N., longitude 17° 30′ W. During the next 24 hours it drifted about 3° toward the east, and then moved southward, as on the 27th it was central near the Scilly Islands, with a rising barometer and decreasing winds. From the 24th to the 26th as shown on Charts XIV to XVI, inclusive, the storm developed into one of the most violent encountered in years. Especially interesting was the newspaper account of the experience of the Cunard liner *Aquitania* which was evidently near the center on the 25th. Some idea of the force of the sea can be gathered by the fact that 10 ports on the "B" deck 50 feet above the water line were smashed in, and 40 feet of the teak-wood coping which inclosed the windows on the shelter deck, 60 feet above the water line, were swept away. Capt. Sir James Charles, R. N. R., stated he had never seen higher seas or known it to blow harder than it did from the night of the 24th until the following afternoon.

The weather was fine until 8 p. m. on the 24th, when it began to blow hard from the southeast. By midnight it had veered to the southwest, reaching hurricane force. The *Aquitania* was now evidently near the center, as the barometer had dropped to 28.23 inches. The ship slowed down to 12 knots by the engines, and for 12 hours only made 5 knots in actual speed. There was little decrease in the force of the wind for 24 hours, and the rough sea continued until the 28th. A large number of other vessels were caught in this gale, and storm logs follow:

American S. S. *Blair:*

Gale began on the 24th, wind N. Lowest barometer 28.94 inches at 10 a. m. on the 24th, wind N, 11, in latitude 49° 43′ N, longitude 29° 42′ W. End on the 25th, wind NNW. Highest force of wind 12, N.; shifts SE.–N.

British S. S. *Paludina:*

Gale began on the 24th, wind SSE. Lowest barometer 28.60 inches at 9 p. m. on the 24th, in latitude 49° N, longitude 21° W. End on the 26th, wind NNW. Highest force of wind 12, WNW. to NNW.; shifts W–W by N.

American S. S. *Anaconda:*

Gale began on the 24th, wind SSE. Lowest barometer 28.11 inches at 3 p. m. on the 24th, wind ESE, 6, in latitude 50° N, longitude 23° 45′ W. End on the 25th wind NNW. Highest force of wind 11; shifts ESE.–SE.–S.–SW.–W.

Apparently the storm center passed over us about 3 p. m. on the 24th, the time of our lowest barometer. At that time the wind dropped almost to calm, followed by a rising barometer and an abrupt change of wind to the west. The wind then rapidly increased from this direction, causing the crest of waves to fall back in great smothers of foam.

British S. S. *Lexington:*

Gale began on the 24th, wind SW. Lowest barometer 27.87 inches at 5 a. m. on the 25th, wind SSE., 10, in latitude 51° 10′ N, longitude 19° W. End at noon on the 26th, wind NNW. Highest force of wind 11; shifts SSE.–NW. by W.

It is possible that the barometric reading of 27.87 inches may be somewhat too low, although the *Lexington* is equipped with a mercurial barometer that appears to be reliable, judging from the Greenwich mean noon observations.

From the 18th to the 22d there was a second tropical storm as shown on Charts VIII to XII, inclusive. This was central on the 18th near latitude 29° N, longitude 79° W, and moved slowly northeastward until the 22d, when the center was near latitude 35° N, longitude 70° W. It was only natural that this disturbance should be confused with the one just described, as on the 18th, 19th, and 20th the centers of the two areas of low pressure were not far apart. This disturbance, while of a tropical nature was not fully developed, and no unusually low barometric readings were reported. Storm logs and special report follow:

American S. S. *S. B. Hunt:*

Gale began on the 18th, wind NE. Lowest barometer 29.66 inches at 2 a. m. on the 21st, wind N, in latitude 34° 23′ N, longitude 75° 54′ W. End on the 22d, wind NE. Highest force of wind 10, N; shifts NE.–N. Heavy rain squalls at intervals.

British S. S. *Rathlin Head:*

Gale began on the 20th, wind NNE. Lowest barometer 29.60 inches on the 21st, wind NNE., 8, in latitude 34° 07′ N, longitude 75° 35′ W. End on the 21st, wind N. Highest force of wind 10, NNE.; shifts, veering and backing between N. and NE.

Cuban S. S. *Paloma:*

8 a. m. on the 19th, in latitude 32° 04′ N., longitude 76° 40′ W., barometer 30 inches, wind ENE., 8. High easterly sea.

8 p. m. on the 19th, in latitude 31° 15′ N., longitude 76° 40′ W., barometer 29.87 inches, wind SSE., 7. Squalls and lightning in NW.

At 10 p. m. furious squalls of wind and rain, vivid lightning all around, wind increasing to almost hurricane force from SE. Sea nearly flattened out.

Midnight on the 19th, barometer 29.82 inches, wind SE., 11 (high force).

1 a. m. on the 20th, barometer 29.72 inches (lowest reading), wind SE., 8.

2 a. m. on the 20th, in latitude 31° N., longitude 76° 20′ W., barometer 29.77 inches, wind SE., 7. Sky breaking up. Center of disturbance apparently passed to westward of ship, a long line of black clouds being seen to west, lying SW. and NE., with clear sky above and below (traveling northerly).

On the 18th there was a fairly well developed area of low pressure over the eastern section of the steamer lanes that on the 19th was central off the north coast of Scotland, as shown on Charts VIII and IX.

On the 27th and 28th westerly gales prevailed off the coast of Labrador, as shown by following storm log:

British S. S. *Manchester Spinner:*

Gale began on the 27th, wind WNW. Lowest barometer 29.46 inches at 3 a. m. on the 28th, wind WNW., 10, in latitude 53° N., longitude 54° 19′ W. End on the 29th, wind NW. by W. Highest force of wind 10, WNW., steady WNW.

From the 27th to 30th heavy weather was reported over to middle and eastern sections of the steamer lanes. Storm logs:

American S. S. *Ala:*

Gale began on the 27th, wind WSW. Lowest barometer 29.18 inches at 10:30 a. m. on the 28th, wind W., 10, in latitude 52° 39′ N., longitude 35° 34′ W. End on October 1, wind N. Highest force of wind 10, W. by S. to WNW. Shifts; WSW–WNW.

Danish S. S. *Oscar II:*

Gale began on the 29th, wind S. Lowest barometer 29.35 inches at 8 p. m. on the 29th, wind SSW., 7, in latitude 57° 58′ N., longitude 14° 35′ W. End on the 30th, wind SSW. Highest force of wind 9, steady SSW.

NORTH PACIFIC OCEAN.

By WILLIS E. HURD.

The early receipt of the very complete typhoon report for the REVIEW from Rev. José Coronas, S. J., of the Manila Observatory, renders it unnecessary to remark in detail in this résumé upon the weather in the Far East for September. Father Coronas notes the behavior of an August-September typhoon, and records the movements of four others whose histories are wholly contained within the latter month. The Weather Bureau has received reports from vessels slightly involved in all these storms. In the first, on September 11, the Japanese S. S. *Taiyo Maru*, Captain Nagana, Observer Kamada, Yokohama to Hongkong, encountered winds from the NW., force 8, in latitude 25° 49′ N., longitude 121° 20′ E., lowest corrected pressure, 29.27 inches. The observer notes:

At 4 a. m. wind N. by W., force 7, ugly, threatening weather; barometer showed 29.46, corrected. Then we avoided the typhoon, putting engine slow down, and taking ship's course on north.

This storm, which prevailed over the lower Loochoos on the 10th, is reported to have been one of the severest ever experienced there. On Miyako Island alone about 2,000 houses were destroyed.

The influence of the second typhoon, that of the 11th to 21st, was felt by the British S. S. *Talthybius* on the 19th and 20th, in latitudes 22° to 23° N., longitudes 115° to 117° E.; highest wind force ENE., 8, on the 20th.

The third typhoon, which formed on the 13th to 14th over the Marianas, is mentioned by Father Coronas as having been last seen on the 21st in about 35° N., 144° E., but reports which have since become available would indicate that it continued eastward and into still higher latitudes. The American S. S. *West Iran* had a gale, force 7, on the 22d, in 39° 10′ N., 157° E., with shifts from S. to WNW., lowest pressure, 29.43. It seems unquestionable that this vessel was affected by that cyclone, and still further reports indicate as fully that the typhoon, now become an extratropical storm of much reduced intensity, moved still farther northward until on the 25th it was over the upper reaches of Bering Sea.

The Dutch S. S. *van Overstraten*, Hongkong to Amoy, fell under the influence of the fourth typhoon, that of the 25th to 29th. The storm moved to the eastward and northward of the vessel's positions on the 28th and 29th. The steamship therefore remained in the left-hand semicircle and experienced little beyond northeasterly to northwesterly gales and rough seas up to the time the storm entered the China coast near 26° N.

Tropical storms were not confined to the Far East during September, however, for two violent cyclones were reported from the hurricane region off the west coast of Mexico. The first was observed on September 1 by the American S. S. *West Catanace*, Capt. A. W. M. Knip, Balboa to San Pedro. Strong easterly and southeasterly gales to hurricane winds were encountered by this vessel from 4 a. m. until noon, between 17° 06′ N., 102° 50′ W., and 17° 16′ N., 103° 04′ W. Said Captain Knip:

Tried at 4 a. m. to bring wind on 4 points starboard bow, but ship refused to haul up in wind, and decided to keep running. In fact, thought to have success, as barometer started to rise between 4 and 5 a. m. After 5 barometer steady, sea increasing. After 6 barometer dropped, and before 6 a. m. a heavy sea struck starboard side, doing some damage. Tried again to bring ship up in wind, but in vain. At 7 a. m. barometer had dropped again. Took opportunity from lull in wind to bring ship up in the sea, but could not bring her further than NE 6 N. Decided to keep that course. Barometer dropping fast between 7 and 8. Ship laying fine and shipping very little water. Sea heavy, but not dangerous. After 8 a. m. barometer rising fast, wind hauling and sometimes moderating. Between 8 and 9 clearing in SW. Between 8 and 10 weather moderating and wind hauling after heavy rain squalls, and sky clearing at times, but about 11 a. m. wind increasing to 12 accompanied by terrific rains. After 11:30 weather moderating fast.

NOTE.—At 7:30 a. m. antennæ parted and could not be repaired on account of the storm. Repaired the same during the afternoon and at 6 p. m. sent out advisory to all ships in vicinity, asking also for their weather report, but didn't get any reply, although wireless operator heard advisory repeated by several steamers.

This storm was apparently moving in a course parallel with the coast. It is unfortunate that no other information concerning it is at hand.

On September 9-10 the American S. S. *Bessemer City*, Capt. John Murphy; observer, Second Officer David Polowe, Honolulu to New York, passed through the "eye" of a cyclone in 16° 12′ N., 113° 44′ W. The vessel experienced gale winds, beginning from NNE., 7, from 4 a. m. of the 9th until noon of the 10th, and hurricane winds from 11 a. m. to 11 p. m. of the 9th, except from about 3:30 p. m. to nearly 5 p. m., during which time calms to light airs accompanied the passage through the storm center. The "eye" was estimated to be from 15 to 18 miles in diameter. This size, coupled with the fact that the *Bessemer City* and the disturbance were moving in opposite directions and the vessel so long involved, suggests a hurricane of extraordinary dimensions, larger probably than any other of this locality of which there is trustworthy information.[1]

Of the subsequent movement of the storm, no further data are available. Mr. Polowe suggests that:

The place of disappearance of the confused seas gives us our probable true point of origin of the cyclone (and) makes the parabolic nature of the track at once apparent. This point lies in latitude 16° N. and longitude 113° W. Since the eastern limit of the trade winds is soon reached, the disturbance probably recurved at 20° N., then traveled N. or NNE. and most likely was dissipated against the rocky and mountainous coasts of Lower California.

The pressure alignments over the eastern part of the ocean for September, 1922, showed a persistent low-pressure area over the Gulf of California or adjacent territory, with the North Pacific high-pressure area occupying the major portion of the central region from the 180th meridian to the California coast. This anticyclone was broken only from the 20th to the 26th, when it was pushed westward and southward and cut into two centers by a powerful disturbance central over the Gulf of Alaska.

The Aleutian LOW lay to the southward of Alaska from the 1st to the 3d of the month. It disappeared on the 4th, and on the 5th low pressure covered the islands

[1] Numerous instances like those here mentioned are at hand of extremely valuable though incomplete data concerning the cyclones of west Mexican waters. The Weather Bureau is especially desirous of obtaining all available information about these storms so that their histories may be established, if possible, and is taking opportunity at this time to call the attention of seamen to its needs.

to the westward, where it showed some intensity until the 8th, then weakening until the 11th, when it became negligible. On the 14th the Gulf of Alaska was again the center of an area of low pressure which fluctuated in movement and intensity until the 21st, when it spread to the southward with greatly increased energy. On the 22d to 24th its influence was such that it dominated most of the eastern half of the region previously occupied by the anticyclone, causing strong westerly and northwesterly gales. Several trans-Pacific steamships crossed this storm area. Among them the British S. S. *Empress of Asia* reported the lowest observed corrected pressure reading, 28.90 inches, at 7 p. m. of the 23d, in 50° 05′ N., 140° 29′ W. On the 26th the storm weakened and began moving inland.

About this time the Aleutian LOW proper redeveloped west of Alaska, apparently consequent upon the entrance into Bering Sea of the typhoon of the 13th to 25th, previously mentioned, and thence to the end of the month it fluctuated across the whole Alaskan region.

On the 30th west-southwesterly gales were observed near 45° 25′ N., 164° E. It was the reported beginning of a storm which, early in October, produced violent if not hurricane winds to the eastward.

Considering the eastern portion of the ocean, as represented by the island stations of Dutch Harbor, Midway Island, and Honolulu, pressure during September was above the normal. The excess at the first-named station, based on p. m. observations, was 0.21 inch. The highest pressure was 30.46 inches, recorded on the 17th, the lowest, 29.04 inches, on the 7th. At Midway Island the plus departure was 0.03 inch. The highest pressure here, 30.16 inches, occurred on the 18th, the lowest, 29.82, on the 29th. At Honolulu the plus departure was approximately 0.02 inch. The highest pressure, 30.10, occurred on the 26th, the lowest, 29.89, on the 12th.

Fog was observed by a large percentage of the vessels traversing the northern sailing routes. It was well distributed throughout the month in both eastern and western waters, and some observers reported it for several consecutive days covering many degrees of longitude.

FOUR SEVERE TYPHOONS IN THE FAR EAST DURING SEPTEMBER, 1922.

By Rev. JOSÉ CORONAS, S. J.

[Weather Bureau, Manila, P. I.]

There were four severe typhoons in the Far East during this month. All formed in the Pacific. Two went to China after striking Meiacosima and Formosa, respectively; another traversed the Babuyanes Islands and northern Luzon in the Philippines; and the last remained in the Pacific, recurving northeastward to the southwest and west of the Bonins.

The Meiacosima and China typhoon.—This typhoon was shown in our weather maps of September 7 to 9 over the Pacific between the Ladrone Islands and the Philippines, about 500 or 600 miles to the east of northern Luzon. At 6 a. m. of the 10th, it could be easily situated northeast of Luzon, between 127° and 128° longitude E., 20° and 21° latitude N., moving northwest. The center passed over the Meiacosima group of islands during the night of September 10 to 11, the barometer of Ishigakihima station having fallen to 740.4 mm. (29.15 inches), at 1 a. m. of the 11th, and the wind from WSW., having reached its maximum velocity of 30 meters per second (67 miles per hour), at 10 p. m. of the 10th. The typhoon inclined to WNW. after traversing Meiacosima and entered China during the night of the 11th–12th, passing over Wenchow where it caused great destruction and terrible losses, especially in the river. The typhoon, once in China, recurved northeastward to the west of Shanghai during the night of the 12th and early morning of the 13th. It reached the Shantung Promontory on the morning of the 14th, and northern Korea at about noon of the same day; but it seems that on that day, at least in the afterooon, it was only a depression of no great importance.

The Babuyanes and Ilocos typhoon.—We do not hesitate to call this one of the most remarkable typhoons observed in the Philippines in many years, particularly as to its abnormal track. It formed over the Pacific, on the 11th to 12th, to the west of the Ladrone Islands, between 15° and 16° latitude N. and near 139° longitude E. It moved first W. by N., then NW. by W., until 6 a. m. of the 16th, when near the Balintang Channel it recurved to WSW., to SW., and even to SSW., following the last-named direction very near the western coast of Luzon from Laoag to Bolinao. At about the latitude of Bolinao the typhoon moved for a few hours to SW. until in about 16° latitude, between 118° and 119° longitude it recurved back to NW., thus tracing a track very similar to a typhoon barographic record. A good number of steamers experienced the violence of the storm in the China Sea, among them the *Loong Sang*, the *Susana II*, and the *Tango Maru*, all the captains having been much surprised at its remarkably abnormal track.

Following are some of the barometric minima observed in Luzon during the typhoon:

	Longitude.	Latitude.	Barometer.
	° ′	° ′	*Mm.*
Aparri	121 38	18 22	734.55 (28.92) at midnight, 16th.
Cape Bojeador	120 36	18 31	728.40 (28.68) at 6:40 a. m., 17th.
Laoag	120 35	18 12	732.40 (28.84) at 7 a. m., 17th.
Vigan	120 23	17 34	737 (29.02) at 2 p. m., 17th.
San Fernando Union	120 19	16 37	739.73 (29.12) at 6:15 a. m., 18th.
Bolinao	119 53	16 24	735.41 (28.95) at 6 a. m., 18th.
Iba	119 58	15 20	745.18 (29.34) at 4 a. m., 18th.

The barometric minima of the *Loong Sang*, *Susana II*, and *Tango Maru* were:

	Longitude.	Latitude.	Barometer.
	° ′	° ′	*Mm.*
Loong Sang	118 32	16 46	735.06 (28.94) at 1 a. m., 19th.
Susana II	117 30	18 33	738.64 (29.08) at 4 p. m., 19th.
Tango Maru	116 11	20 39	747.76 (29.44) at 4 a. m., 20th.

It has been reported that in Fuga Island (Babuyanes Islands) the barometric minimum was as low as 695 or 696 mm. (27.36 or 27.40), that there was one hour of vortical calm observed, and that only one house was left standing after the typhoon.

Following is the position of the typhoon for 6 a. m. and 2 p. m. of the 16th to 20th:

	Latitude.	Longitude.
	° ′	° ′
16th—6 a. m.	19 35	124 15
2 p. m.	19 25	123
17th—6 a. m.	18 35	120 45
2 p. m.	17 45	120
18th—6 a. m.	16 35	119 25
2 p. m.	16	118 45
19th—6 a. m.	17 15	117 15
2 p. m.	18	116 40
20th—6 a. m.	18 45	115 10
2 p. m.	19 05	114 05

After 2 p. m. of the 19th the typhoon moved WNW., or W. by N., and it is very probable that it filled up on the 21st near the northern part of Hainan or the southern China coast north of Hainan.

The typhoon of the Ladrones and the Bonins.—This typhoon seems to have formed on the 13th to 14th over the Ladrone Islands, about 250 miles north of Guam, where a gale from the southwest quadrant was observed for a good number of hours on the 15th and 16th. The typhoon moved slowly NW. on the 14th to 17th and recurved gradually to NE. on the 18th and 19th southwest and west of the Bonins. A gale from the S. was reported on the 20th by the station of Chichijima. The typhoon was situated at noon of the 21st in about 144° longitude E. and near 35° latitude N., moving northeastward.

The typhoon of Formosa and China.—The last typhoon of the month appeared on the 25th over the Pacific about 300 miles to the east of San Bernardino Strait. The first part of the track before the 25th is not certain, but probably it formed north of Yap and west of Guam on the 24th near 139° longitude E. and 13° latitude N., and moved westward until the 25th or 26th, when it inclined northwestward. The typhoon was situated at 6 a. m. of the 27th near 125° longitude E. and 16° latitude N., moving NW. by N. At 6 a. m. of the 28th, the center was near or over the Batanes Islands, and in the afternoon of the same day it traversed Formosa, moving still NW. by N. On the 29th, in the early morning, the typhoon entered China not far from 119° longitude E. and 26° latitude N.

Besides the typhoon just mentioned, a low-pressure area traversed Luzon, to the south of Manila, moving westward on the 23d. Once in the China Sea it developed into a depression or typhoon which moved probably WNW, and finally filled up in about 111° longitude E. and 16° latitude N.

Before finishing this article we may add that the last typhoon of August, after passing to the west of Shanghai, recurved NE. toward Korea and the Sea of Japan. It was felt severely in Korea during the night of September 3 to 4.

NOTES ON WEATHER IN OTHER PARTS OF THE WORLD.

British Isles.—During the month roughly half the area of the British Isles received a rainfall below the average. * * * The deficiencies were nowhere very large, amounting to more than 40 per cent only in the Western Highlands. * * * The rainfall over the British Isles was rather more uniform than is usual at the season.

The general rainfall expressed as a percentage of the overage was: England and Wales, 123; Scotland, 87; Ireland, 117; British Isles, 110.

In London, Camden Square, the mean temperature for September was 55.5° F., or 2.2° F. below the average.[1]

Switzerland.—ROME, September 14.—Reports from the Alps say that snow is falling heavily. At some places it has reached a foot in depth, especially around Mont Blanc, Simplon, and St. Gothard. In the Tyrol the temperature has fallen to winter levels in contrast to the excessive heat of a few weeks ago.—*New York Herald, September 15, 1922.*

China.—A typhoon broke over Chefoo (Shantung) on the 2d and lasted for 36 hours, but the damage done was not very extensive.[1]

Philippine Islands.—MANILA, September 19.—Serious damage is believed to have resulted from a typhoon which has swept over the Philippines for the last 36 hours.—*New York Herald, September 19, 1922.*

Australia.—Excellent rains were recorded throughout South Australia during the month and there was every prospect of a really good harvest. The other States also had good harvests.[1]

Brazil.— * * * The distribution of rain in the north and central regions was very irregular, some parts having a fall exceeding the normal and others a deficit. In the southern area the rainfall averages 39 mm. below normal. Small high-pressure areas with very active wind circualtions prevailed throughout the month and temperatures were generally high. The state of the crops was satisfactory on the whole.[1]

[1] *Meteorological Magazine*, October, 1922.

DETAILS OF THE WEATHER IN THE UNITED STATES.

GENERAL CONDITIONS.

A warm, dry month in practically all parts of the country. Drought was most severe south of the 40th parallel; in Kansas, North Dakota, and parts of the upper Lake region, the upper Ohio Valley, and in the District of Columbia, however, rainfall was above normal. (*See* inset on Chart IV.)

The dry weather was rather definitely related to the pressure distribution and the latter naturally was conditioned by the movement in latitude of cyclones and anticyclones, particularly the slow southeastward drift of the latter across the Lake region, New England, and the Middle Atlantic States, as shown by Charts I and II.

CYCLONES AND ANTICYCLONES.

By W. P. DAY.

No really important storms were charted within the area of the United States proper; however, there were three storms of tropical or near tropical origin in the western Atlantic Ocean adjacent to our coast. The two storms, marked "III" and "V" on the chart were the small typical vortices of young tropical cyclones or hurricanes. The third (No. VI), larger and more far-reaching in its effects, developed on the south side of a strong anticyclone, the consequent constriction of the isobars between the two centers of action causing winds

of whole gale force which died down as the anticyclone was disintegrated on passing off unto the Gulf Stream. On the morning of the 21st this storm had on its periphery the small vortex of the hurricane marked "V" on the chart, the latter apparently continuing as a separate disturbance. Lacking reports over that portion of the Atlantic, the further history of this interesting pair is not now known.

Cyclones.	Alberta	North Pacific.	South Pacific.	Northern Rocky Mountain.	Colorado.	Texas.	East Gulf.	South Atlantic.	Central.	Total.
September, 1922.	5.0	.....	.....	1.0	.....	.....	1.0	1.0	2.0	10.0
Average number, 1892-1912, inclusive.....	4.1	1.1	0.4	0.6	0.7	0.3	0.4	0.2	0.7	8.5

Anticyclones.	North Pacific.	South Pacific.	Alberta.	Plateau and Rocky Mountain Region.	Hudson Bay.	Total.
September, 1922.....	4.0	.....	2.0	.....	2.0	8.0
Average number, 1892-1912, inclusive.....	2.1	1.0	3.5	0.7	0.6	7.9

FREE-AIR CONDITIONS.

By L. T. SAMUELS, Meteorologist.

Free-air temperatures were, in general, above the average for the month. (*See* Table 1.) Departures at the surface and lower levels conformed closely with those shown in Climatological Chart III. Exceptions in this respect may be explained as follows: The negative departures found at the surface and 250-meter level at Broken Arrow are very likely a result of the large percentage of kite flights made during the early morning and evening hours, at which times wind conditions were most favorable. The small negative departures found at Due West at all levels would seem to be due to the very short period from which present averages are now obtainable. During the first part of the month, when abnormally high temperatures prevailed generally over the country east of the Rocky Mountains, every aerological station reported maximum temperatures exceeding its previous records for September. These occurred in most cases both at the surface and at various levels above. An examination of the prevailing wind direction at these times revealed a southerly component in every case, thus giving additional evidence of the close relation between free-air temperatures and the source of the air supply.

Relative humidities were mostly below the average for both upper and lower levels, but departures were small in practically all cases.

Vapor pressure departures were in general agreement with those for temperature. During the latter part of the month when drouth conditions were prevalent over large sections of the Plains States and the region east of the Mississippi River, it was noted that vapor pressures at the surface and in the upper levels remained appreciably below their averages. These departures were especially large at the southern stations and very likely account for the large negative departures found at Broken Arrow and Groesbeck in Table 1.

In Table 2 are shown the resultant winds for the month and their averages. The larger southerly components for the month compared to the average are in striking agreement with the positive temperature departures previously referred to.

Pilot-balloon observations at Washington and surrounding stations on the 26th showed complete reversals of the wind direction above the 1,500 meter level from those at the surface. This region was in the southern part of an anticyclone and easterly surface winds shifted to westerly at comparatively low altitudes. As is usually found under such conditions the surface-temperature gradients from south to north were steep, and thereby were instrumental in reversing the surface-pressure system a short distance above.

A significant feature of the month was the westerly winds observed in the lower and upper levels at San Juan on the 17th and 18th, a direction exactly opposite to that usually found in this latitude. In the discussion of "Storms and weather warnings" during the month by E. H. Bowie in this number of the REVIEW, reference is made to the disturbance suddenly appearing off the east Florida coast on the morning of the 18th. The abnormal westerly winds observed in the lower and upper levels at San Juan on the previous day seem to have been intimately connected with the disturbance shown by later surface observations to have been in the vicinity of the Florida coast. The winds at Santo Domingo, Dominican Republic, likewise had a westerly component in the lower levels on the 17th and in the upper levels on the 18th.

The following stations reported pilot-balloon observations showing wind velocities of 30 m. p. s. or higher.

Station.	September.	Velocity.	Direction.	Altitude.
		m. p. s.		*m.*
Ellendale, N. Dak.....	8	33	WSW.....	4,400
Do.....	15	33	WNW.....	7,400
Do.....	26	40	WNW.....	28,200
Lansing, Mich.....	20	30	NNE.....	15,000
Do.....	26	30	N.....	11,200
Lee Hall, Va.....	16	31	W.....	9,780

The observation at Ellendale on the 26th, referred to above, was made with a single theodolite and, as such, must be taken with reservation at such a great altitude.

Easterly movement of the atmosphere above 10,000 meters was observed by means of pilot balloons at the following stations.

Station.	September.	Station.	September.
Aberdeen, Md.....	15	Key West, Fla.....	2, 5, 12
Bolling Field, D. C.....	17, 18	Camp Knox, Ky.....	6
Camp Bragg, N. C.....	22	Lansing, Mich.....	20, 27, 28, 29
Broken Arrow, Okla.....	4, 15, 22	Madison, Wis.....	26, 27, 28
Drexel, Nebr.....	26	Royal Center, Ind.....	21, 22, 26, 29
Ellendale, N. Dak.....	19	San Juan, P. R.....	30
Groesbeck, Tex.....	1	Washington, D. C.....	28
Ithaca, N. Y.....	30		

A number of single-theodolite pilot-balloon observations exceeding 15,000 meters in altitude were made during the month but, since double-theodolite observations above this altitude are as yet unavailable, the reliability of these results must remain, to a large extent, uncertain.

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during September, 1922.*

TEMPERATURE (°C.).

Altitude. M. S. L. (m.)	Broken Arrow, Okla. (233m.)		Drexel, Nebr. (396m.)		Due West, S. C. (217m.)		Ellendale, N. Dak. (444m.)		Groesbeck, Tex. (141m.)		Royal Center, Ind. (225m.)	
	Mean.	Departure from average.	Mean.	Departure from average.	Mean.	Departure from average.	Mean.	Departure from average.	Mean.	Departure from average.	Mean.	Departure from average.
Surface	22.9	−1.0	20.3	+1.5	24.3	−0.4	15.2	+0.4	25.1	+0.3	24.2	+1.9
250	22.8	−0.9	.....	.....	23.9	−0.4	.....	.....	24.8	+0.7	24.0	+1.9
500	22.3	+0.3	19.6	+1.2	21.1	−0.7	15.7	+0.9	23.9	+1.4	21.7	+1.9
750	21.2	+0.6	18.9	+1.6	19.3	−0.8	16.7	+2.4	22.5	+1.5	19.8	+1.7
1,000	19.7	+0.5	18.4	+2.1	18.1	−0.7	16.3	+3.0	21.1	+1.3	18.2	+1.6
1,250	18.3	+0.5	17.4	+2.2	17.0	−0.5	15.4	+3.1	19.5	+1.0	16.6	+1.5
1,500	17.0	+0.6	16.1	+2.1	15.7	−0.4	14.4	+3.2	17.9	+0.6	14.7	+1.2
2,000	14.4	+0.6	13.3	+2.0	13.0	−0.3	11.9	+3.2	14.9	0.0	12.3	+1.5
2,500	11.2	+0.4	9.9	+1.8	9.9	−0.3	8.8	+3.1	12.2	−0.1	9.5	+1.3
3,000	8.0	+0.2	6.4	+1.5	6.6	−0.3	6.1	+3.4	9.7	0.0	6.6	+0.9
3,500	4.6	+0.1	2.9	+1.0	3.3	−0.3	3.5	+3.5	6.5	−0.6	3.8	+0.8
4,000	1.6	+0.2	−0.2	+0.8	−0.1	−0.3	1.8	+4.3	3.1	−1.2	0.8	+0.5
4,500	−1.9	+0.1	−3.6	+0.5	−4.6	−0.3	0.2	+5.1	.....	.....	.....	.....
5,000	.....	.....	−5.4	+1.3	.....	.....	−1.9	+5.6	.....	.....	.....	.....

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during September, 1922*—Continued.

RELATIVE HUMIDITY (%).

Altitude. M. S. L. (m.)	Broken Arrow, Okla. (233m.)		Drexel, Nebr. (396m.)		Due West, S. C. (217m.)		Ellendale, N. Dak. (444m.)		Groesbeck, Tex. (141m.)		Royal Center, Ind. (225m.)	
	Mean.	Departure from average.	Mean.	Departure from average.	Mean.	Departure from average.	Mean.	Departure from average.	Mean.	Departure from average.	Mean.	Departure from average.
Surface	62	−4	60	−4	59	−3	69	+4	69	−8	56	−7
250	62	−4	.....	.....	60	−2	.....	.....	69	−8	56	−7
500	58	−7	60	−2	67	+1	66	+2	68	−9	57	−7
750	57	−7	54	−5	69	+2	58	−3	69	−7	59	−5
1,000	57	−6	51	−6	67	+1	54	−5	69	−4	60	−3
1,250	56	−7	51	−4	65	+1	51	−5	71	0	62	0
1,500	54	−7	52	−1	62	0	48	−5	72	+4	62	+1
2,000	53	−4	51	0	57	−1	44	−6	70	+9	59	+1
2,500	54	+2	55	+3	56	−1	43	−6	61	+5	56	+1
3,000	53	+4	59	+6	54	−1	44	−5	51	−3	56	+4
3,500	55	+3	59	+8	47	−1	46	−1	42	−9	59	+8
4,000	52	0	56	+6	47	−1	43	−2	50	+3	66	+1.5
5,500	67	+7	58	+5	49	−1	41	−2	.....	.....	.....	.....
4,000	.....	.....	52	+1	.....	.....	40	−1	.....	.....	.....	.....

VAPOR PRESSURE (*mb.*).

Surface	17.16	−2.69	14.09	−0.02	17.75	−1.43	11.84	+0.90	21.84	−2.05	17.02	+0.27
250	17.09	−2.64	.....	.....	17.59	−1.36	.....	.....	21.48	−1.61	16.84	+0.29
500	15.82	−1.87	13.37	−0.13	16.46	−1.00	11.66	+0.89	20.10	−0.91	15.14	+0.37
750	14.50	−1.38	11.89	−0.21	15.18	−0.94	10.68	+0.81	18.68	−0.35	14.05	+0.72
1,000	13.37	−1.06	10.95	−0.04	13.87	−0.74	9.57	+0.64	17.10	+0.24	13.14	+0.99
1,250	12.16	−0.86	10.25	+0.34	12.60	−0.52	8.61	+0.65	16.15	+0.97	12.24	+1.29
1,500	10.82	−0.68	9.51	+0.64	11.30	−0.48	7.68	+0.53	14.87	+1.38	11.07	+1.32
2,000	8.85	+0.03	7.96	+0.80	9.23	−0.41	6.15	+0.35	12.11	+1.71	9.22	+1.55
2,500	7.17	+0.87	6.80	+0.93	7.89	−0.29	4.89	−0.03	9.04	+0.95	7.19	+1.44
3,000	5.52	+1.07	5.74	+0.89	6.87	−0.29	4.31	+0.10	6.43	−0.15	5.93	+1.57
3,500	4.41	+0.83	4.64	+0.75	5.81	−0.29	3.88	+0.28	4.23	−0.99	5.52	+2.16
4,000	3.07	+0.47	3.67	+0.43	5.31	−0.29	3.35	+0.28	3.53	−0.53	5.21	+2.37
4,500	2.92	+0.79	3.31	+0.55	4.85	−0.29	3.03	+0.27	.....	.....	.....	.....
5,000	.....	.....	2.91	+0.61	.....	.....	2.65	+0.39	.....	.....	.....	.....

TABLE 2.—*Free-air resultant wind directions and velocities (m. p. s.) during September, 1922.*

Altitude, m. s. l. (m.)	Broken Arrow, Okla. (233m.)				Drexel, Nebr. (396m.)				Due West, S. C. (217m.)				Ellendale, N. Dak. (444m.)				Groesbeck, Tex. (141m.)				Royal Center, Ind. (225m.)			
	Mean.		Average.		Mean.		Average.		Mean.		Average.		Mean.		Average.		Mean.		Average.		Mean.		Average.	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.
Surface	S. 29° E.	2.1	S. 1° W.	3.6	S. 2° W	2.7	S. 14° W	2.0	N. 62° E.	3.2	N. 72° E.	2.1	S. 75° W.	0.9	N. 79° W.	1.0	N. 84 °E.	1.6	S. 23° E.	1.7	S. 24° W.	1.2	S. 57° W.	1.5
250	S. 29° E.	2.1	S. 1° W.	3.7	.....	.....	.....	.....	N. 58° E.	2.8	N. 68° E.	1.8	.....	.....	.....	.....	S. 85° E.	2.4	S. 20° E.	2.4	S. 28 °W.	1.5	S. 57° W.	1.8
500	S. 14° E.	2.9	S. 10° W.	5.1	S. 2° W.	3.7	S. 14° W.	2.6	N. 54° E.	3.6	N. 64° E.	2.1	S. 44° W.	0.9	W.	1.2	S. 69° E.	3.1	S. 13° E.	4.0	S. 31° W.	3.4	S. 54° W.	3.2
750	S. 8° E.	3.2	S. 15° W.	5.8	S.	4.7	S. 27° W.	3.8	N. 47° E.	3.6	N. 47° E.	1.9	S. 49° W.	2.4	S. 76° W.	1.8	S. 66° E.	3.4	S. 8° E.	4.5	S. 35° W.	4.2	S. 61° W.	4.1
1,000	S. 3° W.	2.8	S. 22° W.	5.6	S. 16° W.	4.8	S. 36° W.	4.1	N. 45° E.	3.8	N. 32° E.	1.9	S. 56° W.	3.5	S. 74° W.	2.5	S. 64° E.	3.9	S. 8° E.	4.7	S. 43° W.	4.6	S. 69° W.	4.9
1,250	S. 16° W.	2.5	S. 26° W.	5.5	S. 32° W.	5.0	S. 51° W.	4.4	N. 41° E.	4.4	N. 22° E.	2.4	S. 64° W.	4.1	S. 75° W.	3.1	S. 64° E.	4.0	S. 8° E.	4.8	S. 54° W.	5.2	S. 72° W.	5.9
1,500	S. 33° W.	2.4	S. 35° W.	5.5	S. 45° W.	5.2	S. 61° W.	5.0	N. 40° E.	5.1	N. 14° E.	2.9	S. 68° W.	4.7	S. 82° W.	4.0	S. 62° E.	4.3	S. 10° E.	4.7	S. 60° W.	5.9	S. 76° W.	6.6
2,000	S. 43° W.	2.5	S. 41° W.	6.4	S. 60° W.	5.1	S. 70° W.	6.0	N. 32° E.	4.5	N. 7° E.	2.8	S. 75° W.	6.2	S. 82° W.	5.5	S. 62° E.	4.2	S. 9° E.	4.5	S. 64° W.	8.3	S. 76° W.	8.7
2,500	S. 50° W.	2.4	S. 43° W.	5.5	S. 68° W.	5.6	S. 78° W.	7.6	N. 41° E.	6.1	N. 18° E.	3.0	S. 72° W.	7.0	S. 84° W.	7.4	S. 70° E.	4.9	S. 13° E.	4.4	S. 66° W.	11.8	S. 78° W.	10.3
3,000	S. 54° W.	3.1	S. 36° W.	6.3	S. 70° W.	7.7	S. 82° W.	9.3	N. 42° E.	6.7	N. 40° E.	3.9	S. 83° W.	9.7	S. 86° W.	9.5	S. 89° E.	5.1	S. 11° E.	4.3	S. 65° W.	14.7	S. 76° W.	12.7
3,500	S. 60° W.	3.4	S. 42° W.	5.4	S. 69° W.	10.1	N. 89° W.	10.5	N. 43° E.	7.0	N. 43° E.	7.0	S. 82° W.	12.6	S. 85° W.	10.9	N. 58° E.	5.9	S. 6° E.	3.9	N. 86° W.	14.0	S. 85° W.	12.7
4,000	S. 43° W.	5.1	S. 62° W.	6.7	S. 89° W.	11.3	N. 76° W.	12.5	N. 53° E.	9.0	N. 53° E.	9.0	W.	14.8	N. 84° W	12.6	N. 60° E.	4.6	S. 10° E.	4.6	N. 42° W.	19.9	N. 77° W.	10.9
4,500	S. 65° W.	5.8	S. 85° W.	7.4	N. 67° W	15.9	N. 67° W.	14.8	N. 45° E.	13.1	N. 45° E.	13.1	N. 67° W.	16.7	N. 70° W.	15.8	.....	.....	.....	.....	.....	.....	.....	.....
5,000	.....	.....	.....	.....	N. 75° W.	16.7	N. 68° W.	16.3	N. 45° E.	13.8	N. 45° E.	13.8	N. 45° W.	14.4	N. 88° W.	13.7	.....	.....	.....	.....	.....	.....	.....	.....

THE WEATHER ELEMENTS.

By P. C. DAY, Meteorologist in Charge of Division.

PRESSURE AND WINDS.

During September the development of the continental high-pressure area over the United States, characteristic of the colder months of the year, signs of which are frequently observed in August, is usually well under way in nearly all parts of the country. The only exception to this is in the extreme southeastern part where the occasional recurving of tropical storms tends to a further lowering of the average pressure as compared with August. In the Canadian Northwest, immediately east of the mountains there appears to be a slight temporary halt in the development of the winter-high area, and pressure there is slightly lower than in August. Indications of this are also noticed in the adjacent portions of the United States. To the westward of the mountains and over the eastern Provinces the average pressure for September increases over that for August, the excess becoming fairly large in the Maritime Provinces.

During September, 1922, cyclonic activity was at a low ebb, and no extensive or important storms occurred within the continental United States, although several storms of tropical origin approached the southeastern coast districts. On the other hand, anticyclones were slightly in excess of the normal, were well defined, covered wide areas, and persisted to an unusual extent over the more eastern districts.

For a month as a whole, the average pressure was above normal in all parts of the United States and Canada, save locally over the Pacific Coast States, and the British Northwest Provinces, where it was slightly less than the September normal.

The average pressures were likewise greater than those for August in all districts, save in California and extreme southern Florida. The increases above the August values were usually large over the districts from the middle Mississippi Valley northeastward to the Canadian Maritime Provinces.

In the absence of important cyclones, high winds were confined mainly to the Atlantic coast sections which came under the influence of the tropical storms moving northeastward near the coast during the latter part of the second and the early part of the third decade, but nowhere were the winds of marked severity.

On account of rather persistent high pressure over the central-eastern districts, the prevailing winds from the Great Plains eastward assumed the courses of those usually attending anticyclones, northeasterly on the middle and south Atlantic coasts, easterly over the Gulf States, southerly in the Plains States, and mostly from the southwest over the Great Lakes. In New England and the adjacent portions of New York, southerly winds prevailed, while in the far West they were likewise mainly from southerly points, save along the immediate Pacific coast, where they were from north to northwest.

Local high winds due to thunderstorm activity, were much less frequent than in the preceding month, and damage from such storms was likewise far less.

A list of the more important storms as obtained from newspaper and other sources appears at the end of this section.

TEMPERATURE.

September, 1922, will pass into history as a month marked by unusual persistence of warm and delightfully pleasant days, with few abrupt and important temperature changes.

Important periods of unusual warmth were on the 1st and 2nd, when maximum temperatures frequently above 100° and locally as high as ever observed in September, were reported from Arizona and New Mexico northeastward to the middle Mississippi Valley; from the 4th to 8th over much of the central valleys and southern districts, the 6th being the warmest ever reported in September at numerous points in the upper Mississippi Valley, the warmth extending into the Ohio Valley and eastern districts during the 7th and 8th, where likewise some record-breaking day temperatures were reported; on the 11th and 12th high temperatures were observed over the districts from the Rocky Mountains westward, the 11th being particularly warm in portions of Oregon and adjacent States, where the maximum temperatures were as high as, or locally higher than, ever before observed so late in the month.

Day temperatures of 100° or higher were observed locally in all the States at some time during the month, save those along the northern border from the Great Lakes eastward and in some of the Middle Atlantic Coast States.

The highest temperature recorded during the month, 118°, occurred in southern Arizona on the 1st, and in southern California on the 16th.

The coldest periods of the month were mainly during the last week, although in the Middle Plains they occurred considerably earlier, and in the far Northwest they occurred during the first week of the month. Freezing temperatures were confined mainly to the mountain regions of the West, and to the more Northern States. In many of the Central and Southern States generally killing frosts had not occurred at the end of the month.

The lowest temperature reported during the month, 11°, was observed on the 29th at a point in the mountains of Idaho.

The mean temperature of the month, as a whole, was above the normal in practically all parts of the United States and Canada, the only exceptions being narrow strips along the east Gulf and South Atlantic coasts, and over the extreme eastern portion of the Canadian Maritime Provinces, where there were monthly means slightly less than normal.

Throughout much of the country from the Rocky Mountains westward it was the warmest September in many years. In California, and other fruit-growing sections near by, the continued heat with almost constant sunshine greatly favored the ripening and drying of the various crops.

PRECIPITATION.

The most notable feature of the weather during the month under discussion, was the general lack of rainfall over nearly all parts of the country. Of the 48 States only 4 had average precipitation equal to or above the normal, namely Florida, Ohio, Michigan, and North Dakota.

The early part of the month had rather frequent local showers over considerable areas in the western mountain regions, and over the northern border States as far eastward as the Great Lakes, as well as in portions of the Missouri Valley. About the 9th general showers set in from the middle Great Plains northeastward to the upper Lakes and gradually spread to the eastward during the following two or three days, bringing the most important precipitation of the month to large areas in the central valleys and eastern districts.

Near the middle of the month there was considerable precipitation over the Gulf States, local falls up to more than 5 inches being reported in 24 hours or less on the east Texas coast, where heavy rains continued from the 15th to 20th. About the end of the second decade there was considerable precipitation over the central valleys, and during the first few days of the third decade there was more or less precipitation along the immediate Atlantic coast from Florida to Chesapeake Bay.

The last decade of the month was without material rainfall over the greater part of the country, and as the precipitation during the preceding portions had been insufficient over large areas, much of the country at the end of the month was suffering from severe drought. This was particularly the case in districts from the Mississippi Valley eastward, where locally the periods without material precipitation were the longest of record.

Despite the general dryness over the country as a whole, a few localities had unusually heavy rains. In southern Florida, Fort Myers reported more than 17 inches, and at points near the southern Texas coast more

than 18 inches occurred, Corpus Christi reporting the greatest monthly precipitation in the history of the station. Likewise in Michigan, Port Huron with a total fall of 6.38 inches had the wettest September in 50 years, although practically all this amount fell before the 15th.

In the vicinity of Washington, D. C., one of the heaviest rainfalls of record occurred during the early morning of the 2d. This storm [1] was not associated with the significant features usually attending heavy precipitation, and was extremely local in character. The region of heaviest precipitation appeared to have been central over Prince Georges County, Md., where at Cheltenham nearly 6 inches fell within a comparatively short period. From this point the amounts diminished to slightly over 5 inches at Ferry Landing in Calvert County, a few miles southeast of Cheltenham, and to a similar amount at Washington, D. C., a somewhat greater distance to the northwest. From these points the amounts diminished rapidly, particularly toward the Virginia side, where only moderate falls were reported to the westward of the counties bordering the Potomac River.

[1] For a detailed description of this storm see p. 487 of this REVIEW.

RELATIVE HUMIDITY.

Throughout the length and breadth of the country the relative humidity, even more uniformly than the precipitation, was below normal, though the variations from normal were usually not so large as the general drought conditions would indicate. A few small areas in New England, the Lake region, the far Southwest, and the coast districts of Washington, had monthly averages slightly above normal.

Over the Great Plains and western mountain districts the monthly means ranged from 10 to 15 or even 20 per cent less than the average, the larger amounts generally being associated with the evening observation.

SEVERE LOCAL STORMS.

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau.]

Place.	Date.	Time.	Width of path. (yards).	Loss of life.	Value of property destroyed.	Character of storms.	Remarks.	Authority.
			Yards.					
Needles, Calif.	1					Wind	Houses reported blown down and several persons killed. Velocity of wind estimated 90 miles.	New York Herald (N. Y.); official, U. S. Weather Bureau.
Bismarck, N. Dak.	2		4,400			Wind and hail	Damage to buildings, trees, etc. Path of storm 2½ miles wide and 60 miles long.	Official, U. S. Weather Bureau.
Yuma (north of) and Mohave and Yavapai Counties, Ariz.	2					Rain	Heavy rains caused three serious breaks in the main canal of the Yuma irrigation project. Bridges and culverts washed out and highways damaged in Mohave and Yavapai Counties.	Do.
Binghamton, N. Y.	6	P. m.				Wind and rain	Heaviest damage to trees and streets. Cellars flooded, and streets blocked by fallen trees and branches.	The Press (Binghamton, N. Y.).
Johnson City, Tenn.	4					Rain	Portions of the town flooded damaging stocks of goods in the basements of several business houses.	Official, U. S. Weather Bureau.
Connecticut coast	6	P. m.				Wind, rain and hail.	Traffic delayed, wires and trees blown down. Lives of many on the sound endangered and several persons reported missing.	New York Sun; Tribune (N. Y.).
Fellsburg, Kans.	8	P. m.				Wind and rain	Several buildings demolished.	Wichita Eagle (Kans.).
Corpus Christi, Tex., and adjacent territory.	15-20				$103,000	do	Streets, bridges and culverts damaged.	Official, U. S. Weather Bureau.

STORMS AND WEATHER WARNINGS.

EDWARD H. BOWIE, Supervising Forecaster.

WASHINGTON FORECAST DISTRICT.

Aside from frost warnings on a number of days for the lowlands of New Jersey and for the more northern and elevated districts of the Altantic States and the Ohio Valley, the important warnings issued during the month were in connection with two storms of the western Atlantic. The first of these originated in low latitudes east of the Lesser Antilles, the French S. S. *Mont Rose* encountering it about 200 miles east of Martinique. This vessel received slight damage. Moving west-northwestward this disturbance passed the vicinity of St. Martin on the 16th on a northwest course and later recurved and passed over Bermuda during the early morning of the 21st. At Hamilton, Bermuda, the lowest barometer reading reported was 28.72 inches, the wind reaching hurricane velocity. Preliminary advices concerning this disturbance were issued on the 14th and they were continued daily until after the disturbance passed to the northward of Porto Rico, after which time the complete absence of reports made the issue of authentic advices impossible. On its approach to Bermuda, warning of increasing winds and rain were sent by radio to vessels in the vicinity of Bermuda.

While the first of these disturbances was in progress another developed off the east Florida coast, the first evidences of it appearing the morning of the 18th, when northeast warnings were displayed along the coast from Cape Henry, Va., southward to Brunswick, Ga. Later during the same day northwest storm-warnings were displayed at and between Jacksonville and Jupiter Inlet, Fla. This disturbance increased in intensity and moved slowly northwestward during the 18th. On the morning of the 19th its center was near latitude 30° N. and longitude 78° W., and moving more to the northward, but slowly. Warnings were repeated on the 19th and vessels off the South Atlantic coast were again advised to exercise caution. From its position on the 19th this disturbance advanced north and then northeastward and passed off Cape Hatteras in an easterly direction on the 22d. On the early afternoon of the 20th storm-warnings were ordered displayed on the coast northward from the Virginia coast to Delaware Breakwater and the morning of the 21st the display was extended northward on the coast to Boston, Mass. No observations have

been received of the lowest barometer readings in the immediate center of this disturbance, but the fact that winds of hurricane velocity occurred off the North Carolina coast would lead to the supposition that the disturbance was one of major intensity, but not actually of tropical origin. So far as known no American vessels were destroyed in either of these disturbances. It is a fact of importance, however, that the Diamond Shoals Lightship was blown 12 miles from its moored position by the second of these disturbances. Details concerning these two disturbances will be found elsewhere in this number of the REVIEW.—*Edward H. Bowie.*

CHICAGO FORECAST DISTRICT.

No general frost warnings were issued during the month. Unseasonable warm weather prevailed throughout the Chicago Forecast District until the 8th, when warnings were issued for the northern Rocky Mountain region and the northeastern slope. After that date warnings were issued for limited areas on several dates. No warnings were issued, however, for sections farther south than western and northern Nebraska, northern Iowa, and the central portions of Wisconsin and lower Michigan. At the end of the month killing frost had occurred at only three stations in the district, as follows: Yellowstone Park, Wyo., on the 8th; Valentine, Nebr., on the 19th; and Sault Ste. Marie, Mich., on the 25th.

Following the warm spell the first part of the month, frost warnings or advisory messages were sent to points in the cranberry regions of Wisconsin on 15 dates. The lowest temperature registered was 20° at Mather on the 16th. Warnings were also issued for the tobacco region of Wisconsin on the 15th, 16th, and 19th; however, no damaging frosts occurred.

Special daily fire-weather warnings were continued to the district forester at Missoula, Mont., until September 14. Daily fire-weather warnings for northeastern Minnesota were sent to the State forester at St. Paul until September 20.

Special forecasts were issued for the Kansas Free Fair, which was held at Topeka from September 11 to September 15, inclusive; and for the Illinois State Fair, which was held at Springfield from the 16th to the 23d, inclusive.

There were no storms on the Great Lakes during the month. The only warnings issued were small-craft warnings for the lower Lakes from Sandusky eastward on the 10th.—*Chas. L. Mitchell.*

NEW ORLEANS FORECAST DISTRICT.

Disturbed conditions prevailed off the Texas coast in the vicinity of Corpus Christi from the 17th to the 20th, with squally weather south of Matagorda Bay on the 17th and during the night of the 19th–20th. Anticyclones of considerable extent prevailed in the interior of the United States at the time and winds were mostly from the northeast. These conditions were preceded and attended by excessive rainfall on the Texas coast, over 13 inches being recorded at Corpus Christi during the period of the 15th–20th. Northeast storm warnings were displayed on the Texas coast from Galveston to Corpus Christi during the afternoon and night of the 17th. The stormy conditions, however, did not extend as far north as Galveston. No other warnings were issued or required during the month.—*R. A. Dyke.*

DENVER FORECAST DISTRICT.

Although a number of areas of low and high pressure of considersble intensity advanced from the North Pacific coast southeastward or eastward over the northern Rocky Mountain region and the Missouri Valley, no cyclones or anticyclones of importance crossed the Denver district. As a whole, the month was much drier than the average, and it was also one of the warmest Septembers on record.

On the morning of the 9th a warning was issued for frost at the higher elevations of southern Utah, and on the morning of the 28th of frost at the higher elevations of northern Arizona and in northern and western Utah. These warnings were justified by the occurrence on the following mornings of minimum temperature favorable for frost, except on the morning of the 29th at Salt Lake City, where the weather was cloudy and the temperature did not fall below 50°.

A warning of probable frost, issued for northeastern Colorado on the morning of the 15th, was not verified, owing to the fact that the crest of a high-pressure area of unusual intensity, which was over southern Saskatchewan and western North Dakota, did not advance as far southward as was expected.

No reports of frosts wers received from any of the regular stations of the District during the month.—*J. M. Sherier.*

SAN FRANCISCO FORECAST DISTRICT.

Two well-marked storms from the North Pacific during the month passed inland far enough south to give rain in the northern portion of this district. The rainfall was quite generous in western Washington but in other sections it was light.

A period of very warm weather prevailed over the southern portion of the district from the 7th to the 25th and over the northern portion from the 10th to the 19th. Records for high temperatures in September were broken on the 10th, at Red Bluff and Roseburg, and equaled on the 11th, at Portland.

Light frost occurred in eastern Washington and Idaho on the 8th, in southern Idaho and Nevada on the 28th and 29th, and killing frost in eastern Oregon on the 28th.

Fire-weather warnings were issued in California on the 22d, and to the forest supervisor at Wenatchee on the 16th.

Advisory warnings of a severe storm in the North Pacific moving southeastward, were sent to Washington and Oregon stations on the 23d, warning vessels about to sail for Alaska and the Orient.

Southwest storm warnings were ordered at Washington and Oregon stations on the 25th. These were not verified but the magnitude of the storm is believed to have justified them.

Rain warnings were issued in northern California on the 26th, but the rain was confined to the coast sections.—*G. H. Willson.*

RIVERS AND FLOODS.

By E. W. GRAEFF, Temporarily in Charge.

The lower Rio Grande River was in flood at Rio Grande City, Tex., on September 21 and 22, with a crest stage of 19.0 feet on the 21st, or 4.0 feet above the flood stage. Warnings of this rise were issued on the 20th.

Heavy rains fell between the 12th and 21st. These rains swelled the Rio San Juan, a tributary from Mexico, which caused a flood of serious proportions from McAllen, Tex., to the Gulf. The damage was very small, as the levees had been strengthened and most of the crops harvested.

At San Benito, Tex., a damage of $50,000 resulted, due to injury to fruit trees, rendering of roads impassable, etc.

Low water has set in in practically all of the other rivers throughout the country. In the Ohio River navigation was suspended for a distance of 500 miles, from Cairo northward, being the lowest stage in that portion of the river during the last 15 years.

Flood stages during September, 1922.

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
WEST GULF DRAINAGE.					
Rio Grande:	*Feet.*			*Feet.*	
Rio Grande city, Tex.	15	21	22	19.0	21

MEAN LAKE LEVELS DURING SEPTEMBER, 1922.

By UNITED STATES LAKE SURVEY.

[Detroit, Mich., Oct. 5, 1922.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.[1]			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during September, 1922:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	602.69	580.33	572.33	246.03
Above or below—				
Mean stage of August, 1922	+0.06	−0.23	−0.17	−0.53
Mean stage of September, 1921	+0.02	+0.29	+0.16	+0.60
Average stage for September, last 10 years	−0.07	−0.43	−0.18	−0.19
Highest recorded September stage	−1.39	−3.10	−1.61	−1.58
Lowest recorded September stage	+1.20	+0.67	+1.05	+2.03
Average relation of the September level to:				
August level		−0.20	−0.30	−0.40
October level		+0.20	+0.30	+0.40

[1] Lake St. Clair's level: In September, 575.19 feet.

INFLUENCE OF WEATHER ON CROPS AND FARMING OPERATIONS.

By J. WARREN SMITH, Meteorologist.

September, 1922, on the whole, was generally warm for the season, with abundant sunshine and scanty precipitation. The middle portion of the month was cool, however, from the extreme upper Mississippi Valley eastward, with general frosts in the northern border States east of Montana, but owing to the advanced condition of crops, comparatively little harm resulted. Considerable frost damage occurred in Idaho and some harm in Washington and Oregon during the first part of the month. Under the influence of warm, sunshiny weather, late crops matured rapidly, especially during the latter part of the month, and conditions were favorable for harvesting.

Considerable rain fell early in the month in the extreme northwestern Great Plains and at the same time soil-moisture conditions were benefited by showers in considerable of the winter-wheat belt, where it had previously been too dry, but moisture continued deficient in many important wheat areas. During the latter part of the month there was insufficient moisture for the preparation of the soil and seeding winter grains in nearly all sections of the country, and this work made generally poor progress, although the soil condition continued satisfactory in some sections, particularly in the extreme lower Missouri Valley, including the eastern half of Kansas.

Late corn was benefited by rain during the first decade of the month in parts of the central and lower Mississippi and lower Ohio Valleys, but moisture was insufficient in most southern districts. The crop matured too rapidly under the influence of high temperatures and drought in parts of Iowa, but the general condition in that State continued fair to very good. Corn matured and dried out very fast during the latter part of the month and cutting made rapid progress, with some husking under way at the close. Very little frost damage occurred and at the close of the month the crop was practically safe from frost in all sections.

There was considerable rainfall in the western cotton-growing States at about the 10th of the month, which relieved the severe drought that had been prevailing in that section. Cotton had reached such an advanced stage of development, however, that the rainfall was not of material benefit, and the crop continued to deteriorate, or to make poor progress in nearly all sections of the belt. There was abundant sunshine and but little rainfall throughout nearly all of the cotton-growing States. These conditions were very favorable for picking and ginning and this work made rapid progress. At the close of the month the crop had been nearly all gathered in southern Texas and picking had been nearly completed in Georgia, except in the northern division.

There was not enough rain for late truck, garden crops, and grasses, and these needed more moisture in nearly all sections of the country. It was too dry, also, for planting fall and winter crops in much of the Southeast, but sugar cane developed satisfactorily in the lower Mississippi Valley. Stock continued in good condition in the central and upper Rocky Mountains and upper Great Plains States, but were thin and poor in most of New Mexico and portions of western Texas. The weather was generally favorable during the month for the maturing and harvesting of fruit, although there was too much moisture for citrus on the lowlands in Florida.

CLIMATOLOGICAL TABLES.[1]

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation, by sections, September, 1922.

Section.	Temperature.								Precipitation.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	77.6	+2.5	Troy	102	4	Florence	45	27	1.51	−2.04	Alaga	4.70	2 stations	0.00
Arizona	76.2	+2.4	Mohawk	118	1	Fort Valley	33	29	1.10	−0.06	Walnut Grove	4.05	3 stations	T.
Arkansas	76.2	+2.3	2 stations	106	[2]6	2 stations	37	12	1.25	−2.08	Jonesboro	5.89	Whitecliffs	T.
California	71.6	+4.5	Greenland Ranch	118	16	Fort Bidwell	20	29	0.05	−0.50	Crescent City	1.79	182 stations	0.00
Colorado	59.7	+2.5	Lamar	102	6	Dillon	18	10	0.41	−1.05	Hermit	2.33	7 stations	0.00
Florida	78.5	−0.8	Marianna	101	4	DeFuniak Springs	49	23	7.75	+0.73	Fort Myers	17.35	Cottage Hill	1.17
Georgia	76.3	+1.3	Bainbridge	104	5	2 stations	46	[2]20	1.57	−2.10	Savannah	7.16	West Point	0.10
Hawaii														
Idaho	59.9	+3.4	Kooskia	101	20	Obsidian	11	29	0.25	−0.71	Priest River Experiment Station.	2.04	33 stations	0.00
Illinois	70.3	+3.3	4 stations	103	[2]2	5 stations	33	[2]26	1.94	−1.57	Chicago	4.37	Greenville	0.44
Indiana	70.6	+3.9	3 stations	103	[2]2	Wheatfield	32	27	1.85	−1.15	Richmond	4.21	South Bend	0.47
Iowa	67.1	+3.7	2 stations	103	6	Washta	31	11	2.03	−1.33	Iowa Falls	4.34	2 stations	0.31
Kansas	73.1	+3.8	Oketo	112	1	2 stations	35	[2]20	2.24	−0.78	Olathe	6.63	4 stations	T.
Kentucky	72.7	+2.7	Hopkinsville	103	[2]6	Farmers	39	26	2.22	−0.54	Lexington	5.99	Farmers	0.60
Louisiana	78.4	+0.9	Plain Dealing	102	6	Minden	51	29	3.00	−0.76	Franklin	8.33	Angola	0.10
Maryland-Delaware	68.6	+1.3	Hancock, Md	100	7	Grantsville, Md	27	26	2.57	−0.53	Cheltenham, Md	7.30	Westminster, Md	0.69
Michigan	62.6	+2.7	Cassopolis	98	8	Humboldt	22	25	3.63	+0.76	Stronach Dam	8.53	Alpena	1.04
Minnesota	62.2	+4.3	New Ulm	105	6	Meadow Lands	24	16	1.97	−0.96	Thief River Falls	5.43	Tracy	0.13
Mississippi	78.0	+1.5	Batesville	105	6	Batesville	46	27	1.38	−1.95	Biloxi	5.33	Louisville	0.00
Missouri	71.7	+2.6	Hollister	107	2	Arcadia	34	27	3.31	−0.57	Harrisonville	8.22	Doniphan	0.15
Montana	59.6	+4.2	3 stations	100	[2]4	Brenner	20	[2]28	0.67	−0.73	Savage	2.47	4 stations	0.80
Nebraska	68.6	+4.7	Falls City	111	1	Gordon	25	19	0.85	−1.25	Stella	4.80	6 stations	0.00
Nevada	65.9	+3.9	Logandale	108	[2]14	Rye Patch	14	29	T.	−0.44	Searchlight	0.19	42 stations	0.00
New England	61.0	+1.4	5 stations	90	[2]6	Van Buren, Me	18	28	2.44	−1.06	Storrs, Conn	6.01	Houlton, Me	0.65
New Jersey	66.7	+1.1	2 stations	94	6	Charlotteburg	27	26	2.26	−1.45	Bergen Point	5.22	Long Branch	0.59
New Mexico	66.6	+2.3	Orogrande	105	[2]1	Elizabethtown	27	23	0.94	−0.53	Pinos Altos	2.77	3 stations	0.00
New York	62.8	+1.9	2 stations	95	[2]8	Indian Lake	22	26	2.01	−1.33	Mount Vernon	4.32	Moira	0.70
North Carolina	71.5	+1.5	Greenville	99	1	Parker	37	27	1.60	−2.23	Wilmington	7.48	Rougemont	0.00
North Dakota	59.8	+3.4	2 stations	104	4	Minot	23	24	2.16	+0.52	Larimore	6.94	New England	0.15
Ohio	68.2	+2.7	4 stations	98	7	Canfield	29	26	2.81	+0.14	Oxford	7.32	Peebles	0.16
Oklahoma	76.4	+2.6	Okeene	109	8	Beaver	40	20	1.41	−1.57	Buffalo	4.20	Sulphur	0.04
Oregon	61.5	+2.9	McMinnville	106	11	La Pine	12	22	0.95	−0.48	Classic Lake	4.98	3 stations	0.00
Pennsylvania	66.3	+3.0	Clearfield	100	9	West Bingham	22	26	1.48	−1.79	Muncy Valley	3.73	York Haven	0.17
South Carolina	75.2	+1.0	3 stations	100	[2]4	Calhoun Falls	47	23	1.15	−2.70	Georgetown	3.68	Rimini	0.00
South Dakota	65.3	+4.4	Tyndall	106	[2]5	2 stations	25	19	0.36	−1.47	Centerville	2.64	6 stations	0.00
Tennessee	73.5	+2.6	Perryville	104	6	Mountain City	36	23	1.77	−1.32	Johnson City	4.40	Bluff City	0.14
Texas	78.4	+1.3	Henrietta	108	8	2 stations	43	11	2.48	−0.34	San Benito	18.21	3 stations	0.00
Utah	64.0	+3.6	St. George	102	[3]12	2 stations	25	30	0.24	−0.87	Escalante	2.10	19 stations	0.00
Virginia	69.3	+1.2	Danville	98	[2]7	Burkes Garden	31	30	1.23	−2.11	Washington, D. C.	6.27	Randolph	0.00
Washington	60.8	+2.7	2 stations	100	12	Snyders Ranch	27	6	1.54	−0.05	Forks	8.08	Kennewick	0.02
West Virginia	67.2	+1.6	Wheeling	100	[2]6	Bayard	25	26	2.14	−0.60	Moundsville	5.64	Upper Tract	0.10
Wisconsin	62.3	+2.8	Meadow Valley	104	6	2 stations	23	[3]17	3.50	−0.03	Rest Lake	6.96	Hayward	1.38
Wyoming	58.4	+4.0	Deaver	100	12	Alta	12	29	0.29	−1.01	Moran	1.68	Hyattville	0.00

[1] For description of tables and charts, see Review, July, 1922, pp. 384-385.

[2] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, September, 1922.*

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.											Mean wet thermometer.	Mean temperature of the dewpoint.	Mean relative humidity.	Precipitation.			Wind.						Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.						Total.	Departure from normal.	Days with 0.01 inch, or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F*		°*F*	°*F.*		°*F*	°*F.*	°*F.*	°*F.*	%	*In.*	*In.*		*Miles.*					*0–10*	*In.*	*In.*
New England.							**62.1**	**+1.6**										**81**	**2.05**	**−1.1**							**4.5**		
Eastport	76	67	85	30.01	30.09	+.06	54.6	−1.2	73	5	62	35	26	47	26	50	48	85	0.96	−2.0	5	5,492	s.	26	nw.	25	11	10	9	5.2	0.0	0.0
Greenville, Me	1,070	6	....	28.94	30.10	.....	55.4	.....	80	30	67	24	28	44	43	....	....	....	1.89	.....	8	....	....	....	....	....	20	1	9	....	0.0	0.0
Portland, Me	103	82	117	30.01	30.13	+.08	60.0	+0.4	81	30	68	38	26	52	29	55	52	78	1.80	−1.4	8	5,504	s.	26	nw.	25	14	7	9	4.4	0.0	0.0
Concord	288	70	79	29.81	30.12	+.06	60.8	+1.7	86	30	73	30	26	49	42	....	....	....	2.72	−0.5	6	2,634	s.	22	nw.	24	13	8	9	4.5	0.0	0.0
Burlington	404	11	48	29.67	30.10	+.04	60.4	+1.5	84	10	71	34	18	50	32	....	....	....	2.21	−1.1	6	7,007	s.	36	s.	9	16	8	6	4.0	0.0	0.0
Northfield	876	12	60	29.18	30.13	+.07	57.8	+3.2	88	10	71	25	26	45	40	53	52	90	2.36	−0.4	5	4,301	s.	26	n.	24	10	10	10	5.3	0.0	0.0
Boston	125	115	188	29.99	30.13	+.06	65.2	+2.0	84	15	73	42	26	57	28	59	55	72	3.66	+0.5	4	5,874	sw.	26	w.	12	15	10	5	4.2	0.0	0.0
Nantucket	12	14	90	30.11	30.12	+.04	63.8	+1.0	82	6	70	48	19	57	20	60	57	85	0.83	−1.9	7	9,156	sw.	36	ne.	21	13	9	8	4.5	0.0	0.0
Rock Island	26	11	46	30.09	30.12	+.04	64.5	+1.1	80	6	70	46	26	60	15	60	58	85	0.84	−2.2	4	9,278	sw.	38	nw.	24	12	11	7	4.3	0.0	0.0
Providence	160	215	251	29.95	30.12	+.05	64.8	+1.6	88	6	74	40	26	56	30	58	55	74	3.28	+0.1	3	6,528	sw.	35	s.	12	14	10	6	4.3	0.0	0.0
Hartford	159	122	140	29.95	30.12	+.05	65.4	+3.7	88	6	75	38	26	55	33	59	56	80	2.06	−1.4	5	4,427	s.	22	sw.	15	12	10	8	4.7	0.0	0.0
New Haven	106	74	153	30.02	30.13	+.06	65.6	+2.1	89	6	73	39	26	57	30	59	56	77	1.86	−1.9	5	5,368	sw.	32	nw.	6	14	10	6	3.9	0.0	0.0
Middle Atlantic States.							**68.6**	**+2.0**										**77**	**1.96**	**−1.4**							**4.3**		
Albany	97	102	115	30.02	30.12	+.05	64.6	+1.5	85	5	74	36	26	55	32	58	55	79	2.41	−0.8	6	4,537	s.	24	s.	11	14	9	7	4.2	0.0	0.0
Binghamton	871	10	84	29.20	30.12	+.05	64.5	+4.5	90	6	76	34	26	53	36	....	....	....	4.13	+1.4	9	2,747	e.	28	n.	6	14	7	9	4.9	0.0	0.0
New York	314	414	454	29.80	30.13	+.05	67.4	+0.6	89	6	74	46	26	60	23	61	58	77	3.05	−0.5	5	7,447	s.	52	nw.	24	15	6	9	4.6	0.0	0.0
Harrisburg	374	94	104	29.74	30.14	+.06	68.9	+4.0	95	6	79	41	26	59	33	60	56	70	0.85	−2.0	3	3,272	s.	19	nw.	24	16	8	6	3.9	0.0	0.0
Philadelphia	117	123	190	30.01	30.14	+.06	69.7	+2.3	93	6	78	47	26	61	25	62	58	72	1.23	−2.2	4	5,787	sw.	26	ne.	25	12	4	14	5.3	0.0	0.0
Reading	325	81	98	29.78	30.12	.....	68.1	.....	94	6	78	40	26	58	32	61	57	76	1.16	−2.5	3	2,849	se.	18	nw.	25	13	11	6	4.5	0.0	0.0
Scranton	805	111	119	29.28	30.14	+.07	65.6	+3.4	93	6	77	34	26	54	36	58	55	76	1.18	−1.7	3	3,402	n.	22	nw.	6	14	8	8	4.7	0.0	0.0
Atlantic City	52	37	172	30.06	30.12	+.05	68.6	+1.8	86	6	75	45	26	63	21	64	62	81	1.15	−1.9	4	9,703	ne.	48	ne.	21	18	7	5	3.4	0.0	0.0
Cape May	18	13	49	30.13	30.15	+.08	69.2	+0.2	86	5	76	42	26	62	25	64	62	84	2.07	−0.9	3	4,791	n.	24	ne.	21	18	8	4	3.3	0.0	0.0
Sandy Hook	22	10	55	30.10	30.12	.....	68.0	.....	89	6	74	50	26	62	22	62	59	78	1.09	.....	5	8,555	s.	44	nw.	25	15	9	6	3.8	0.0	0.0
Trenton	190	159	183	29.92	30.12	.....	67.2	.....	91	6	77	40	26	57	30	60	57	76	1.75	−1.8	2	6,129	ne.	29	nw.	24	13	8	9	4.6	0.0	0.0
Baltimore	123	100	113	29.99	30.12	+.04	70.8	+2.3	95	6	79	47	26	62	28	63	59	73	2.69	−1.2	4	3,633	e.	16	s.	11	13	10	7	4.5	0.0	0.0
Washington	112	62	85	30.00	30.12	+.04	69.9	+1.8	92	6	80	46	26	60	30	63	60	79	6.27	+2.7	4	3,300	n.	22	w.	11	12	10	8	4.4	0.0	0.0
Lynchburg	681	153	188	29.39	30.13	+.05	70.9	+1.9	96	7	83	46	27	59	36	62	59	76	1.42	−2.2	5	3,314	e.	28	n.	4	17	8	5	4.1	0.0	0.0
Norfolk	91	170	205	30.01	30.11	+.05	73.6	+1.9	92	7	81	58	28	66	24	66	63	78	0.53	−3.5	5	7,463	ne.	30	ne.	21	7	18	5	5.2	0.0	0.0
Richmond	144	11	52	29.97	30.12	+.05	70.6	−0.2	91	7	80	48	26	61	27	64	62	81	0.66	−2.8	2	4,057	ne.	18	ne.	21	13	12	5	4.3	0.0	0.0
Wytheville	2,304	49	55	27.78	30.12	+.05	65.6	+2.0	87	7	78	41	30	53	35	58	56	80	0.74	−2.6	2	2,452	se.	23	w.	11	15	13	2	3.5	0.0	0.0
South Atlantic States.							**74.4**	**+1.0**										**78**	**3.66**	**−1.0**							**4.8**		
Asheville	2,255	70	84	27.81	30.12	+.05	67.8	+2.8	87	7	79	47	23	56	33	59	56	77	1.19	−1.8	5	3,533	se.	24	se.	25	13	12	5	3.8	0.0	0.0
Charlotte	779	55	62	29.27	30.10	+.03	73.5	+2.0	94	2	83	54	27	64	27	64	60	69	1.23	−2.0	4	2,995	ne.	18	ne.	18	13	13	4	4.1	0.0	0.0
Hatteras	11	12	11	30.05	30.06	.00	73.5	−1.0	85	12	78	62	20	69	14	70	68	82	7.89	+2.6	7	8,059	ne.	49	n.	21	6	15	9	5.9	0.0	0.0
Manteo	12	5	42	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Raleigh	376	103	110	29.70	30.09	+.02	72.7	+2.1	91	16	82	54	27	63	25	65	62	76	0.11	−3.2	1	4,575	ne.	22	ne.	20	7	17	6	4.9	0.0	0.0
Wilmington	78	81	91	29.99	30.07	+.02	73.6	+0.5	90	3	81	58	27	66	19	68	66	83	7.48	+2.2	9	5,538	ne.	29	e.	19	9	13	8	5.4	0.0	0.0
Charleston	48	11	92	30.00	30.05	+.01	76.8	+0.2	90	3	83	62	24	70	19	71	69	83	1.13	−4.3	10	8,611	ne.	38	ne.	19	9	12	9	5.6	0.0	0.0
Columbia, S. C	351	41	57	29.71	30.08	+.03	76.2	+2.5	96	4	86	57	21	66	33	67	63	72	2.19	−1.3	6	4,277	ne.	22	ne.	18	13	15	2	4.2	0.0	0.0
Due West	711	10	55	29.35	30.11	.....	74.7	.....	95	4	86	57	27	64	32	....	....	....	0.33	.....	4	5,250	ne.	25	ne.	17	12	14	4	4.5	0.0	0.0
Greenville, S. C	1,039	113	122	29.00	30.08	.....	73.8	.....	92	2	83	54	23	64	30	64	60	68	0.72	.....	5	5,045	ne.	24	n.	4	18	9	3	3.4	0.0	0.0
Augusta	180	62	77	29.87	30.06	+.01	77.1	+1.8	98	4	87	58	21	67	32	68	65	76	1.47	−2.2	4	3,423	e.	26	nw.	4	14	13	3	4.1	0.0	0.0
Savannah	65	150	194	29.97	30.04	+.01	76.4	+1.0	97	4	84	61	21	68	27	70	68	83	7.16	+1.6	8	7,537	ne.	36	ne.	19	6	12	12	5.8	0.0	0.0
Jacksonville	43	209	245	29.96	30.01	+.01	76.8	−1.5	90	4	83	61	23	71	20	72	71	87	6.70	−1.3	16	8,051	n.	42	n.	19	8	8	14	6.0	0.0	0.0
Florida Peninsula.							**80.4**	**−0.7**										**79**	**8.35**	**+0.4**							**6.8**		
Key West	22	10	64	29.93	29.95	+.01	82.2	0.0	90	9	87	71	9	77	17	76	73	76	5.56	−1.2	17	6,329	se.	52	w.	22	2	19	9	6.2	0.0	0.0
Miami	25	71	79	29.95	29.98	.....	80.1	−1.4	89	20	85	70	23	75	15	75	73	79	11.04	+1.4	23	4,413	e.	21	e.	7	2	11	17	7.3	0.0	0.0
Sand Key	23	39	72	29.93	29.96	+.02	80.2	.....	84	5	83	69	24	77	14	76	73	75	1.98	.....	13	8,513	e.	48	w.	22	1	17	12	6.6	0.0	0.0
Tampa	35	79	92	29.95	29.99	+.02	79.0	−0.7	91	3	86	66	23	72	19	72	71	85	8.46	+1.0	23	4.016	e.	27	e.	15	2	15	13	6.9	0.0	0.0
East Gulf States.							**77.9**	**+2.6**										**74**	**1.50**	**−2.4**							**4.1**		
Atlanta	1,174	190	216	28.86	30.08	+.03	75.3	+2.9	94	4	85	59	30	66	23	66	62	69	1.16	−2.4	5	5,895	e.	38	nw.	11	15	8	7	4.0	0.0	0.0
Macon	370	78	87	29.67	30.06	+.03	76.6	+3.7	98	4	87	53	23	66	37	67	63	70	0.57	−2.8	2	4,013	e.	26	nw.	4	17	9	4	3.6	0.0	0.0
Thomasville	273	49	58	29.73	30.02	+.01	78.1	+1.3	97	4	88	57	23	68	29	69	66	74	3.42	−0.8	9	2,921	ne.	19	ne.	11	9	10	11	5.8	0.0	0.0
Apalachicola	36	42	49	29.97	30.01	.....	77.2	.....	90	6	83	63	23	71	20	72	70	83	4.06	.....	12	5,902	ne.	26	se.	8	11	11	8	4.9	0.0	0.0
Pensacola	56	149	185	29.96	30.02	+.02	78.0	−0.5	89	6	84	67	24	72	21	71	69	77	1.94	−3.3	10	7,600	e.	42	ne.	6	13	10	7	4.9	0.0	0.0
Anniston	741	9	57	29.31	30.09	+.06	76.4	+5.1	97	4	89	52	23	64	37	....	....	....	0.44	−3.1	5	3,054	se.	22	w.	4	19	9	2	2.7	0.0	0.0
Birmingham	700	11	48	29.32	30.08	+.05	78.8	+4.8	99	5	90	58	22	67	32	66	62	68	1.54	−2.0	7	3,467	e.	21	se.	10	15	12	3	3.8	0.0	0.0
Mobile	57	125	161	29.96	30.02	+.02	79.4	+1.5	94	7	88	65	21	71	26	71	68	79	3.19	−1.8	10	5,311	ne.	32	e.	17	9	14	7	4.7	0.0	0.0
Montgomery	223	100	112	29.80	30.05	+.03	79.1	+2.8	98	4	89	60	24	69	32	68	64	68	2.56	−0.3	7	3.612	ne.	24	se.	10	19	7	4	3.1	0.0	0.0
Corinth	469	6	....	....	....	....	77.2	.....	99	4	91	50	13	63	39	....	....	....	0.57	.....	6	....	ne.	....	....	....	8	22	0	....	0.0	0.0
Meridian	375	85	93	29.65	30.03	+.01	77.2	+4.5	96	5	88	59	23	66	29	68	64	72	0.16	−3.3	6	2,793	e.	20	e.	14	20	8	2	3.4	0.0	0.0
Vicksburg	247	65	73	29.77	30.05	+.03	77.7	+1.4	95	6	87	59	27	68	25	69	66	73	0.64	−2.7	3	3,353	n.	18	ne.	4	17	11	2	3.7	0.0	0.0
New Orleans	53	76	84	29.95	30.00	+.02	80.8	+1.6	93	6	87	71	23	75	19	73	70	77	0.93	−3.9	6	4.382	se.	23	e.	18	11	12	7	5.1	0.0	0.0
West Gulf States.							**78.6**	**+2.8**										**70**	**3.40**	**−0.1**							**3.6**		
Shreveport	249	77	93	29.76	30.03	+.03	78.8	+3.1	96	8	89	60	12	69	27	69	65	73	1.36	−1.9	5	3.534	ne.	28	se.	9	20	9	1	2.9	0.0	0.0
Bentonville	1,303	11	44	....	....	....	72.6	+3.7	98	7	86	44	12	59	36	....	....	....	1.86	.....	3	....	....	....	....	....	22	4	4	....	0.0	0.0
Fort Smith	457	79	94	29.56	30.02	+.01	78.0	+5.3	101	7	90	53	12	66	32	64	56	55	0.48	−2.7	2	4,380	e.	27	se.	15	23	6	1	2.3	0.0	0.0
Little Rock	357	136	144	29.67	30.04	+.01	77.7	+4.6	100	6	89	56	13	66	30	65	59	62	0.93	−2.3	4	4,417	s.	34	se.	15	21	8	1	2.2	0.0	0.0
Brownsville	57	4	26	....	....	....	80.7	.....	97	7	88	67	26	74	21	....	....	....	12.61	.....	13	....	se.	....	....	....	12	8	10	....	0.0	0.0
Corpus Christi	20	11	73	29.95	29.97	+.02	80.4	+1.4	92	6	86	70	26	75	19	74	72	82	13.80	+9.8	13	8,567	e.	48	ne.	17	11	8	11	5.4	0.0	0.0
Dallas	512	109	117	29.48	30.02	.....	79.4	.....	98	7	90	54	21	68	31	....	....	....	0.68	.....	4	4,755	e.	33	s.	28	20	9	1	3.3	0.0	0.0
Fort Worth	670	106	114	29.29	29.99	.00	79.4	+2.7	99	7	90	56	12	69	29	66	59	57	0.41	−2.5	3	5,276	se.	33	ne.	16	19	9	2	2.6	0.0	0.0
Galveston	54	106	114	29.94	30.00	+.02	80.2	+0.1	91	6	85	70	12	76	16	74	72	79	8.89	+3.5	10	6,662	e.	29	se.	9	13	12	5	4.5	0.0	0.0
Groesbeck	461	11	56	29.52	29.99	.....	78.4	.....	98	7	90	56	12	67	33	....	....	....	1.30	.....	5	4,801	e.	52	e.	2	16	11	3	3.0	0.0	0.0
Houston	138	111	121	29.85	29.99	.....	80.4	+1.9	98	6	89	67	12	72	24	....	....	....	2.34	.....	9	4,526	e.	25	e.	9	15	10	5	3.6	0.0	0.0
Palestine	510	64	72	29.49	30.01	+.02	78.2	+3.5	97	7	88	60	12	68	27	68	65	72	2.48	−0.7	6	3,639	ne.	28	s.	2	10	15	5	4.3	0.0	0.0
Port Arthur	34	58	66	29.95	29.99	.....	78.9	.....	91	6	86	66	12	71	23	72	70	82	2.10	.....	12	5,384	ne.	24	ne.	8	11	10	9	4.8	0.0	0.0
San Antonio	701	119	132	29.26	29.98	+.02	79.6	+2.5	98	7	90	62	22	70	28	68	63	67	0.97	−2.0	8	5,180	ne.	28	ne.	15	15	9	6	4.0	0.0	0.0
Taylor	582	55	63	29.42	30.03	+.06	78.8	+1.9	99	7	89	57	22	68	29	....	....	....	1.25	−1.8	7	4,476	se.	32	e.	9	12	13	5	4.3	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, September, 1922*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.												Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation.			Wind.						Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.						Total.	Departure from normal.	Days with 0.01 inch, or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Direction.	Date.							
	Ft.	Ft.	Ft.	In.	In.	In.	° F.	° F.	° F		° F	° F.		° F	° F	° F.	° F.	%	In.	In.		Miles.									0-10	In.	In.
Ohio Valley and Tennessee.							71.8	+3.5										71	2.36	−0.4											3.0		
Chattanooga	762	189	213	29.29	30.09	+.03	74.8	+2.6	93	4	86	56	23	64	31	65	61	71	0.78	−2.5	5	3,153	nw.	32	nw.	4	18	10	2	3.2	0.0	0.0
Knoxville	996	102	111	29.06	30.10	+.04	73.5	+4.1	92	2	84	55	23	63	29	64	60	70	1.86	−1.0	5	2,885	ne.	21	sw.	4	13	11	6	4.1	0.0	0.0
Memphis	399	76	97	29.67	30.09	+.06	76.3	+2.7	96	8	85	54	27	68	24	66	61	67	1.41	−1.6	7	4,209	n.	26	sw.	10	18	11	1	2.7	0.0	0.0
Nashville	546	168	191	29.52	30.09	+.03	74.2	+2.4	94	2	85	53	26	63	30	65	61	71	3.28	−0.4	5	4,344	ne.	42	ne.	3	16	10	4	3.2	0.0	0.0
Lexington	989	193	230	29.05	30.10	+.03	72.6	+4.7	94	8	82	47	26	63	28				5.99	+3.6	5	7,737	ne.	48	e.	3	19	7	4	2.6	0.0	0.0
Louisville	525	219	255	29.53	30.11	+.05	73.6	+4.9	99	7	86	49	26	64	29	63	58	66	1.39	−1.2	5	5,738	s.	30	n.	24	23	3	4	2.6	0.0	0.0
Evansville	431	139	175	29.63	30.09	+.03	74.6	+3.1	95	8	84	48	26	63	29	64	58	66	2.16	−0.5	4	5,894	ne.	30	sw.	10	20	8	2	2.9	0.0	0.0
Indianapolis	822	194	230	29.23	30.11	+.05	71.2	+4.5	96	2	82	44	25	60	30	61	57	67	1.52	−1.5	5	6,762	sw.	48	nw.	3	21	7	2	2.4	0.0	0.0
Royal Center	736	11	55	29.32	30.11	.....	67.8	.....	96	8	81	39	27	55	37				1.12	.....	5	5,311	sw.	30	nw.	2	16	9	5	3.3	0.0	0.0
Terre Haute	575	96	129	29.47	30.08	.....	71.6	.....	96	2	83	43	26	60	35	62	67	68	0.74	.....	4	5,649	ne.	34	w.	3	18	10	2	3.2	0.0	0.0
Cincinnati	628	11	51	29.44	30.11	+.04	70.6	+3.5	93	2	82	44	26	59	33		59	72	2.93	+0.6	5	3,511	ne.	16	sw.	1	24	3	3	2.2	0.0	0.0
Columbus	824	179	222	29.25	30.11	+.04	69.6	+3.1	93	7	81	45	25	59	29	61	56	68	2.68	+0.2	6	5,589	s.	42	nw.	1	20	6	4	2.8	0.0	0.0
Dayton	899	181	216	29.13	30.07	.....	70.2	+2.8	93	7	81	44	26	59	32	61	57	68	2.46	0.0	7	5,517	sw.	35	sw.	3	25	3	2	2.0	0.0	0.0
Elkins	1,947	59	67	28.12	30.16	+.08	64.5	+2.6	90	8	78	34	26	51	38	56	55	90	1.31	−1.6	6	2,146	nw.	26	nw.	11	16	10	4	4.2	0.0	0.0
Parkersburg	638	77	84	29.48	30.13	+.05	70.4	+4.3	94	7	82	45	26	59	32	62	59	79	3.73	+1.0	4	2,546	se.	18	nw.	24	23	3	4	2.9	0.0	0.0
Pittsburgh	842	353	410	29.23	30.12	+.04	69.6	+3.2	94	8	81	44	26	58	34	60	55	67	1.54	−0.9	3	5,651	sw.	33	nw.	24	19	6	5	2.9	0.0	0.0
Lower Lake Region.							65.6	+2.6										73	1.93	−0.9											4.0		
Buffalo	767	247	280	29.28	30.11	+.05	64.4	+2.0	86	8	71	42	26	58	21	60	57	79	1.25	−1.9	5	8,646	sw.	48	sw.	13	13	8	9	4.9	0.0	0.0
Canton	448	10	61	29.60	30.07	.....	61.2	+1.9	88	10	72	28	26	50	34				0.96	−1.8	7	5,591	sw.	27	w.	27	17	8	5	3.8	0.0	0.0
Oswego	335	76	91	29.73	30.10	+.04	62.9	+1.7	89	9	71	38	26	55	27	58	55	79	2.05	−0.8	9	5,801	s.	34	ne.	6	12	11	7	4.3	0.0	0.0
Rochester	523	86	102	29.55	30.12	+.06	64.3	+1.9	92	8	74	40	26	55	28	58	54	74	1.85	−0.5	6	4,729	sw.	23	nw.	24	16	6	8	4.1	0.0	0.0
Syracuse	597	97	113	29.48	30.12	+.05	63.7	+2.1	87	9	72	36	26	55	27				1.31	−1.5	7	6,002	s.	35	nw.	24	12	12	6	4.8	0.0	0.0
Erie	714	130	166	29.34	30.10	+.04	66.4	+2.8	91	10	74	40	26	58	24	59	55	71	1.72	−1.8	6	7,962	n.	33	nw.	11	15	10	5	3.8	0.0	0.0
Cleveland	762	190	201	29.30	30.12	+.06	67.0	+3.1	92	8	75	42	26	59	24	60	55	70	1.60	−1.6	7	7,780	s.	50	ne.	11	16	8	6	4.1	0.0	0.0
Sandusky	629	62	103	29.44	30.12	+.06	68.6	+3.3	95	8	77	45	26	60	28				1.86	−0.8	5	7,002	ne.	46	n.	11	16	8	6	3.9	0.0	0.0
Toledo	628	208	243	29.44	30.12	+.06	67.6	+3.2	93	7	77	44	25	58	26	60	56	71	2.85	+0.5	7	7,828	sw.	43	sw.	2	18	7	5	3.3	0.0	0.0
Fort Wayne	856	113	124	29.20	30.11	.....	68.4	+2.9	96	8	80	41	26	57	31	59	54	68	1.70	.....	6	4,971	sw.	27	sw.	8	16	12	2	3.3	0.0	0.0
Detroit	730	218	258	29.34	30.13	+.07	67.0	+3.5	93	6	76	46	25	58	26	59	55	72	3.83	+1.4	9	6,235	sw.	35	n.	6	13	12	5	3.9	0.0	0.0
Upper Lake Region.							62.6	+3.4										78	3.72	+0.5											4.6		
Alpena	609	13	92	29.45	30.12	+.09	60.6	+3.0	90	5	70	37	26	51	34	56	53	81	1.04	−2.4	5	6,273	nw.	34	nw.	24	13	12	5	4.8	0.0	0.0
Escanaba	612	54	60	29.43	30.09	+.08	60.2	+3.3	85	2	68	37	25	52	29	55	52	80	4.45	+0.9	9	6,008	sw.	36	n.	7	19	4	7	3.8	0.0	0.0
Grand Haven	632	54	89	29.43	30.10	+.06	62.9	+1.8	91	8	72	38	17	54	28	58	55	81	4.66	+1.5	8	5,705	s.	30	n.	7	13	10	7	4.7	0.0	0.0
Grand Rapids	707	70	87	29.35	30.12	+.07	65.2	+3.4	95	8	75	40	25	55	34	58	55	75	5.04	+1.9	8	2,829	e.	17	nw.	7	13	10	7	4.6	0.0	0.0
Houghton	684	62	99	29.34	30.06	+.06	59.8	+3.7	87	29	68	37	25	51	33				4.50	+1.0	9	6,032	e.	37	w.	23	12	6	12	5.5	0.0	0.0
Lansing	878	11	62	29.18	30.12	.....	64.3	+3.0	94	8	77	36	25	52	41	57	55	84	2.93	+0.3	9	2,462	sw.	14	nw.	24	13	9	8	4.5	0.0	0.0
Ludington	637	60	66	29.41	30.10	.....	61.8	.....	88	8	69	39	17	54	22	58	55	81	4.67	.....	12	5,759	s.	36	sw.	8	17	6	7	3.9	0.0	0.0
Marquette	734	77	111	29.30	30.10	+.10	61.6	+4.8	88	4	70	39	17	53	29	55	51	76	3.26	−0.2	9	6,894	sw.	40	sw.	8	9	8	13	5.9	0.0	0.0
Port Huron	638	70	120	29.42	30.11	+.05	64.0	+2.4	91	6	73	40	26	55	30	58	56	80	6.38	+3.7	10	6,229	ne.	32	s.	9	14	12	4	3.7	0.0	0.0
Saginaw	641	69	77	29.42	30.12	.....	63.4	.....	94	8	74	39	25	53	32	57	54	78	4.77	+1.7	11	4,345	sw.	26	n.	6	15	7	8	4.3	0.0	0.0
Sault Sainte Marie	614	11	52	29.42	30.11	+.09	58.6	+4.3	85	8	69	34	25	48	35	53	51	84	1.13	−2.3	10	4,009	se.	34	nw.	24	11	11	8	5.1	0.0	0.0
Chicago	823	140	310	29.23	30.10	+.06	69.5	+3.2	98	2	76	52	26	63	23	61	56	66	4.37	+1.4	7	6,802	sw.	26	n.	24	18	8	4	3.4	0.0	0.0
Green Bay	617	109	144	29.42	30.08	+.06	63.0	+3.9	90	5	72	39	17	54	26	56	53	78	2.74	−0.4	11	6,572	s.	50	sw.	8	11	10	9	5.5	0.0	0.0
Milwaukee	681	125	139	29.37	30.10	+.07	66.2	+4.7	97	6	74	47	25	59	26	59	55	71	4.63	+1.7	8	6,030	sw.	27	ne.	24	16	6	8	4.6	0.0	0.0
Duluth	1,133	11	47	28.84	30.06	+.08	58.2	+3.1	86	4	67	37	16	49	30	52	49	81	2.23	−1.3	13	8,361	ne.	40	sw.	8	15	8	7	4.2	0.0	0.0
North Dakota.							60.6	+3.4										68	1.93	+0.5											4.3		
Moorhead	940	50	58	28.99	30.00	+.04	61.4	+3.2	97	4	74	36	10	49	42	52	46	66	0.66	−1.6	8	5,155	s.	27	nw.	8	13	7	10	4.4	0.0	0.0
Bismarck	1,674	8	57	28.52	30.02	+.08	61.4	+3.3	98	4	74	35	19	48	44	53	47	68	1.93	+0.7	7	5,336	nw.	46	nw.	2	19	5	6	3.9	0.0	0.0
Devils Lake	1,482	11	44	28.42	29.99	+.05	59.4	+3.8	95	4	71	33	10	47	46	51	46	71	3.30	+1.9	8	5,904	se.	36	w.	1	15	7	8	4.6	0.0	0.0
Ellendale	1,457	10	56	28.46	30.01	.....	61.4	.....	99	4	76	35	10	47	54				1.21	.....	9	8,583	nw.	46	sw.	5	17	4	9	4.1	0.0	0.0
Grand Forks	835	12	89	.....	.....	.....	60.2	.....	96	22	74	33	25	46	50	52	.....	.....	2.11	.....	8	.....	.....	32	sw.	8	13	6	11	.....	0.0	0.0
Williston	1,878	41	48	27.99	29.96	+.03	60.1	+3.5	91	4	73	34	15	47	41	52	47	69	1.91	+1.0	10	4,846	se.	29	se.	5	13	12	5	4.3	0.0	0.0
Upper Mississippi Valley.							68.5	+3.3										72	2.38	−0.9											3.5		
Minneapolis	918	102	208	29.04	30.02	.....	65.6	.....	98	5	76	40	16	56	32	.....	.....	.....	2.16	−1.5	11	7,268	s.	36	se.	3	13	9	8	4.5	0.0	0.0
St. Paul	837	236	261	29.15	30.05	+.06	65.0	+3.7	99	6	75	41	16	55	29	.....	.....	.....	1.82	−1.6	8	7,471	se.	37	se.	3	14	10	6	4.2	0.0	0.0
La Crosse	714	11	48	29.31	30.07	+.06	64.7	+2.5	101	6	76	40	25	54	36	.....	.....	.....	2.34	−1.8	8	2,701	se.	14	s.	5	15	8	7	4.2	0.0	0.0
Madison	974	70	78	29.07	30.10	+.07	65.1	+4.0	97	6	74	45	25	56	29	57	53	73	2.34	−0.8	9	5,332	sw.	25	nw.	8	15	7	8	4.5	0.0	0.0
Wausau	1,247	4	.....	28.78	30.12	.....	60.6	.....	91	6	72	34	25	50	36	.....	.....	.....	2.86	.....	11	.....	sw.	.....	.....	.....	17	4	9	4.2	0.0	0.0
Charles City	1,015	10	49	29.00	30.07	+.07	64.6	+2.9	98	6	76	39	25	53	34	57	54	77	2.22	−0.6	8	3,813	se.	20	se.	28	17	7	6	3.7	0.0	0.0
Davenport	606	71	79	29.43	30.09	+.06	68.9	+4.2	100	6	80	44	25	58	34	60	56	70	1.91	−1.2	7	3,713	sw.	26	nw.	8	18	5	7	3.4	0.0	0.0
Des Moines	861	84	97	29.16	30.06	+.04	68.0	+3.0	96	7	78	43	11	58	30	59	55	72	3.00	−0.1	4	4,319	s.	23	sw.	30	16	9	5	3.5	0.0	0.0
Dubuque	698	81	96	29.36	30.11	+.08	65.9	+1.9	99	6	76	39	25	55	33	58	54	75	3.40	−0.2	5	3,371	s.	18	n.	10	13	10	7	4.3	0.0	0.0
Keokuk	614	64	78	29.42	30.09	+.06	70.0	+3.6	98	7	80	46	26	60	31	61	57	69	2.92	−1.0	6	3,535	s.	24	s.	1	20	2	8	3.2	0.0	0.0
Cairo	358	87	93	29.68	30.06	+.01	74.2	+2.7	96	7	84	52	26	64	27	65	62	74	1.41	−1.1	4	4,371	n.	24	nw.	10	21	4	*5	3.0	0.0	0.0
Peoria	609	11	45	29.44	30.10	+.06	69.6	+5.3	100	6	82	40	27	57	42	61	58	77	2.71	−0.4	5	2,866	s.	17	w.	10	24	3	3	2.1	0.0	0.0
Springfield, Ill	644	10	91	29.40	30.07	+.02	70.9	+3.3	99	2	83	44	26	59	32	61	56	68	1.00	−2.4	5	4,658	s.	26	w.	2	19	6	5	3.0	0.0	0.0
Hannibal	534	74	109	29.51	30.08	+.05	70.2	+2.3	99	1	81	43	27	59	32	.....	.....	.....	3.54	0.0	5	4,792	sw.	38	sw.	2	20	2	8	2.9	0.0	0.0
St. Louis	567	265	303	29.47	30.07	+.03	73.8	+3.7	99	2	84	50	26	64	29	63	57	63	2.49	−0.4	5	7,072	s.	39	sw.	1	22	5	3	2.4	0.0	0.0
Missouri Valley.							70.1	+4.6										61	2.03	−0.7											3.1		
Columbia, Mo	781	11	84	29.24	30.07	+.04	70.8	+3.0	100	1	82	44	27	60	32	.....	.....	.....	3.79	+0.9	7	4,342	s.	28	sw.	2	20	4	6	3.1	0.0	0.0
Kansas City	963	161	181	29.04	30.05	+.03	72.0	+4.5	101	1	81	51	26	63	27	62	56	64	4.50	+0.7	8	6,773	s.	34	n.	8	20	4	6	3.2	0.0	0.0
St. Joseph	937	11	49	29.02	30.04	.....	71.6	.....	104	1	82	45	11	61	30	61	56	68	3.09	.....	7	5,057	s.	29	nw.	8	21	5	4	3.0	0.0	0.0
Springfield, Mo	1,324	98	104	28.69	30.08	+.05	72.7	+4.8	97	1	83	47	11	62	28	61	54	60	0.95	−2.8	5	5,713	s.	28	nw.	16	19	7	4	2.7	0.0	0.0
Iola	984	11	50	29.02	30.04	+.03	72.8	+4.2	102	1	86	46	21	60	35	.....	.....	.....	4.33	+1.0	7	3,861	s.	19	n.	10	21	5	4	3.0	0.0	0.0
Topeka	987	92	107	.....	.....	.....	72.0	+3.7	104	1	83	46	21	61	33	.....	.....	.....	5.51	+2.0	8	6,737	s.	40	w.	2	20	5	5	2.8	0.0	0.0
Drexel	1,299	10	54	28.65	30.02	.....	69.8	.....	102	1	82	44	11	58	35	.....	.....	.....	0.86	.....	7	6,644	s.	31	s.	7	18	8	4	3.2	0.0	0.0
Lincoln	1,189	11	84	28.78	30.02	+.03	72.2	+7.0	106	1	85	45	11	60	37	59	51	58	2.12	−0.5	11	7,096	s.	29	sw.	7	18	6	6	3.2	0.0	0.0
Omaha	1,105	115	122	28.87	30.04	+.01	71.0	+5.2	101	1	82	50	11	60	33	60	56	67	1.29	−1.7	9	4,683	se.	37	n.	2	18	7	5	3.1	0.0	0.0
Valentine	2,598	47	54	27.33	30.01	+.05	66.2	+3.9	97	4	82	30	19	50	46	53	43	52	0.11	−1.7	3	6,120	s.	33	sw.	26	21	7	2	2.7	0.0	0.0
Sioux City	1,135	94	164	28.83	30.03	+.05	68.1	+4.0	99	6	80	45	9	56	34	58	52	63	0.49	−2.0	5	7,687	s.	33	n.	8	13	12	5	3.7	0.0	0.0
Huron	1,306	59	74	28.64	30.03	+.07	66.8	+5.5	98	5	81	36	10	53	43	55	47	59	0.28	−1.4	5	6,562	se.	38	se.	6	21	5	4	2.6	0.0	0.0
Pierre	1,572	70	75	28.34	29.99	+.04	67.6	+3.8	100	21	82	35	19	53	52	54	45	55	0.19	−0.9	2	5,364	e.	52	sw.	4	17	9	4	3.1	0.0	0.0
Yankton	1,233	49	57	28.71	30.01	+.04	69.0	+5.0	101	5	82	40	10	56	37	.....	.....	.....	0.85	−1.6	4	4,997	s.	30	s.	6	11	16	3	4.3	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, September, 1922*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.												Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation.			Wind.					Clear days.	Partly cloudy days.	Cloudy days	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.						Total.	Departure from normal.	Days with 0.01 inch, or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	° *F.*	° *F.*	° *F*		° *F*	° *F.*		° *F*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	%	*In.*	*In.*		*Miles.*								*0–10*	*In.*	*In.*
Northern Slope.							**61.6**	**+4.4**												**52**	**0.52**	**−0.6**										**3.1**		
Billings	3,140	5					63.0		100	4	84	26	29	42	58						0.30		2						20	8	2		0.0	0.0
Havre	2,505	11	44	27.35	29.96	+.02	60.8	+4.4	96	20	76	38	18	46	49	50	42	59			0.68	−0.4	6	4,661	sw.	30	sw.	30	18	9	3	3.3	0.0	0.0
Helena	4,110	87	112	25.84	29.98	+.01	60.6	+4.4	90	20	74	36	29	47	43	48	37	47			0.54	−0.5	5	5,842	sw.	31	sw.	27	13	13	4	3.7	0.0	0.0
Kalispell	2,973	48	56	26.94	29.96	.00	57.8	+3.9	85	20	71	36	29	45	43	48	38	55			0.52	−0.8	6	3,649	nw.	32	sw.	22	18	6	6	4.0	0.0	0.0
Miles City	2,371	48	55	27.49	30.01	+.06	65.8	+4.6	96	21	81	37	29	50	45	51	42	53			0.68	−0.2	2	3,564	s.	36	nw.	7	20	9	1	2.9	0.0	0.0
Rapid City	3,259	50	58	26.66	30.02	+.06	64.4	+5.3	94	4	79	40	19	50	44	50	39	45			0.75	−0.5	3	5,424	w.	36	n.	7	18	8	4	3.1	0.0	0.0
Cheyenne	6,088	84	101	24.13	30.00	+.04	60.8	+3.6	84	17	75	34	10	46	40	47	36	47			0.36	−0.6	5	6,953	w.	40	nw.	2	15	13	2	3.3	0.0	0.0
Lander	5,372	60	68	24.73	30.00	+.04	61.3	+6.1	86	13	77	34	30	45	40	48	37	47			0.02	−1.0	1	3,390	sw.	35	sw.	6	20	10	0	2.8	0.0	0.0
Sheridan	3,790	10	47	26.15	30.02				91	21	80	31	30	42	54	48	39	56			0.08		2	2,928	s.	42	sw.	5	23	5	2	2.4	0.0	0.0
Yellowstone Park	6,200	11	48	23.98	30.02	+.05	54.8	+1.4	80	13	71	25	8	39	44	42	31	47			0.10	−0.9	4	5,345	s.	44	sw.	7	18	11	1	3.0	0.0	0.0
North Platte	2,821	11	51	27.15	30.04	+.07	67.8	+5.7	98	4	84	39	19	52	45	55	48	60			1.00	−0.5	3	4,402	s.	25	n.	18	21	7	2	2.8	0.0	0.0
Middle Slope.							**71.6**	**+4.1**												**52**	**1.12**	**−0.8**										**2.8**		
Denver	5,292	106	113	24.83	30.02	+.06	65.8	+2.9	88	7	79	42	10	53	36	50	37	44			0.54	−0.4	2	4,590	s.	37	n.	17	16	11	3	3.6	0.0	0.0
Pueblo	4,685	80	86	25.37	29.98	+.02	68.3	+3.9	92	17	84	39	21	53	44	51	39	41			0.09	−0.5	2	3,872	e....	34	w.	15	14	14	2	3.8	0.0	0.0
Concordia	1,392	50	58	28.57	30.02	+.03	73.0	+4.9	106	1	85	42	20	61	33	59	52	56			1.35	−1.2	9	6,250	s.	22	s.	13	17	8	5	3.7	0.0	0.0
Dodge City	2,509	11	51	27.47	30.02	+.04	72.4	+4.2	101	1	86	46	20	59	36	58	50	55			1.84	+0.1	8	7,454	s.	30	sw.	3	22	7	1	2.2	0.0	0.0
Wichita	1,358	139	158	28.60	30.01	+.01	73.4	+3.6	100	1	85	49	20	62	30	61	56	62			2.00	−1.1	8	8,583	s....	33	s.	7	21	6	3	2.6	0.0	0.0
Altus	1,410	5					77.2		103	7	92	49	21	63	39						0.50		1		se.				27	1	2		0.0	0.0
Broken Arrow	765	11	52	29.24	30.06		74.4		98	1	87	48	11	62	32						0.66		2	6,874	s.	36	n.	10	22	6	2	2.0	0.0	0.0
Muskogee	652	4					77.4		104	7	93	46	12	62	40						0.30		1		w.				21	8	1		0.0	0.0
Oklahoma City	1,214	10	47	28.78	30.03	+.04	77.0	+4.9	101	8	90	50	11	64	34	62	56	57			0.90	−1.8	3	6,457	s.	31	nw.	10	26	4	0	1.6	0.0	0.0
Southern Slope.							**75.6**	**+2.9**												**53**	**0.66**	**−1.9**										**3.4**		
Abilene	1,738	10	52	28.22	30.00	+.04	77.0	+2.8	99	7	89	49	21	65	36	62	54	54			0.32	−2.8	3	5,451	s.	29	se.	9	21	4	5	3.0	0.0	0.0
Amarillo	3,676	10	49	26.35	30.01	+.05	73.1	+5.4	99	1	86	49	11	60	37	59	52	57			1.41	−1.0	8	7,387	s.	28	n.	9	19	8	3	3.6	0.0	0.0
Del Rio	944	64	71	29.00	29.96	+.02	79.8	+0.9	97	7	89	62	12	70	28						0.78	−1.7	7	3,832	se.	30	se.	29	16	4	10	4.2	0.0	0.0
Roswell	3,566	75	85	26.41	29.96	+.04	72.7	+2.4	99	1	86	48	27	59	40	57	47	49			0.13	−2.2	3	5,049	s.	36	w.	8	20	7	3	2.7	0.0	0.0
Southern Plateau.							**74.0**	**+3.5**												**47**	**0.68**	**−0.2**										**2.2**		
El Paso	3,762	110	133	26.20	29.88	.00	75.6	+2.9	98	2	86	57	21	65	31	60	50	48			1.07	−0.4	6	6,481	e.	34	nw.	1	21	7	2	2.1	0.0	0.0
Santa Fe	7,013	38	53	23.37	29.94	+.01	63.8	+3.2	83	14	76	44	20	52	32	50	42	54			1.07	−0.6	8	3,609	e.	36	ne.	18	16	10	4	3.9	0.0	0.0
Flagstaff	6,908	10	59	23.47	29.93	−.04	59.4	+3.9	83	12	75	37	30	43	40	47		58			1.56		5	4,398	w.	29	w.	2	9	21	0	3.0	0.0	0.0
Phoenix	1,108	11	81	28.68	29.81	.00	85.0	+3.6	107	15	99	64	30	71	39	67	57	45			0.13	−0.9	1	3,709	e.	27	n.	2	26	3	1	1.7	0.0	0.0
Yuma	141	9	54	29.64	29.78	.00	88.4	+4.7	114	15	103	63	30	74	38	72	64	53			1.11	+1.0	3	3,050	sw.	30	n.	2	27	2	1	1.3	0.0	0.0
Independence	3,957	9	41	25.98	29.94	+.08	72.0	+2.9	95	12	88	47	30	56	39	51	31	25			0.00	−0.1	0	3,512	nw.	21	se.	23	29	1	0	0.9	0.0	0.0
Middle Plateau.							**66.5**	**+4.2**												**36**	**0.07**	**−0.6**										**1.7**		
Reno	4,532	74	81	25.51	29.94	−.01	65.4	+5.7	93	11	83	35	29	48	45	48	32	35			0.00	−0.3	0	4,547	w.	33	w.	27	28	2	0	0.5	0.0	0.0
Tonopah	6,090	12	20	24.14	29.93		68.8		88	12	80	40	28	57	27	49	31	26			0.00	−0.5	0	4,411	se.	23	se.	27	26	4	0	1.3	0.0	0.0
Winnemucca	4,344	18	56	25.65	30.00	+.07	62.4	+1.9	91	12	82	32	29	42	52	45	30	35			0.00	−0.3	0	4,308	sw.	25	nw.	27	27	3	0	0.7	0.0	0.0
Modena	5,479	10	43	24.69	29.95	+.03	65.1	+4.9	90	16	82	38	30	48	44	49	35	40			0.04	−1.1	1	6,834	sw.	44	s.	27	24	3	3	2.6	0.0	0.0
Salt Lake City	4,360	163	203	25.66	29.96	+.01	69.2	+4.8	92	16	81	47	9	57	34	52	33	37			0.01	−0.8	1	4,821	nw.	30	sw.	6	24	4	2	1.9	0.0	0.0
Grand Junction	4,602	60	68	25.44	29.98	+.03	70.2	+3.8	91	14	84	51	29	56	37	53	42	42			0.38	−0.6	5	3,883	se.	30	s.	3	16	11	3	3.2	0.0	0.0
Northern Plateau.							**64.7**	**+3.4**												**42**	**0.29**	**−0.5**										**2.9**		
Baker	3,471	48	53	26.48	30.03	+.04	59.9	+2.9	91	20	77	30	29	43	42	47	31	45			0.11	−0.6	3	4,233	se.	21	se.	26	22	5	3	2.4	0.0	0.0
Boise	2,739	78	86	27.17	29.99	+.02	66.0	+4.1	96	3	82	33	29	50	40	51	38	38			0.01	−0.4	1	2,908	se.	24	nw.	7	24	6	0	1.6	0.0	0.0
Lewiston	757	40	48	29.19	29.98	.00	67.2	+3.7	100	19	84	41	29	50	50						0.51	−0.1	6	1,872	w.	24	nw.	4	17	6	7	3.5	0.0	0.0
Pocatello	4,477	60	68	25.52	29.97	+.01	64.0	+3.3	89	20	80	33	29	48	40	47	32	35			0.07	−0.8	2	5,171	se.	34	sw.	27	20	8	2	2.6	0.0	0.0
Spokane	1,929	101	110	27.96	29.98	.00	62.6	+3.4	92	19	76	37	8	49	43	51	41	51			0.64	−0.4	4	3,640	sw.	22	s.	27	11	13	6	4.4	0.0	0.0
Walla Walla	991	57	65	28.91	29.98	−.02	68.4	+3.0	95	11	81	47	29	56	35	54	43	43			0.41	−0.5	5	3,247	s.	23	w.	7	19	9	2	2.7	0.0	0.0
North Pacific Coast Region.							**59.9**	**+1.7**												**78**	**2.39**	**+0.2**										**5.6**		
North Head	211	11	56	29.81	30.03	.00	56.8	+0.6	80	10	60	49	18	53	21	55	53	89			3.24	+1.4	13	10,935	n.	50	s.	27	7	4	19	6.7	0.0	0.0
Port Angeles	29	8	53	30.01	30.04		54.4		79	11	62	41	19	46	28						1.38	−0.5	10	3,154	s.	30	w.	30	10	8	12	5.9	0.0	0.0
Seattle	125	215	250	29.91	30.04	+.03	59.8	+1.9	78	11	67	49	8	52	25	54	51	76			1.19	−0.6	9	6,185	s.	38	sw.	6	5	16	9	5.9	0.0	0.0
Tacoma	213	113	120	29.82	30.05	+.03	59.7	+2.1	79	25	68	43	23	51	29						1.65	−0.8	12	3,903	sw.	25	sw.	27	6	14	10	5.9	0.0	0.0
Tatoosh Island	86	9	57	29.91	30.01	.00	54.2	+1.2	68	24	58	46	15	51	18	53	52	92			7.23	+1.1	15	9,971	s.	50	sw.	6	5	3	22	7.6	0.0	0.0
Yakima	1,071	5					63.0		96	12	82	34	24	44	49						0.43				nw.								0.0	0.0
Medford	1,425	4					65.4		104	10	86	35	28	45	55						0.50		4		se.				23	3	4		0.0	0.0
Portland, Oreg	153	68	106	29.86	30.02	−.01	63.8	+2.1	93	11	74	48	18	54	35	57	53	71			1.90	+0.1	8	3,964	nw.	22	sw.	27	9	12	9	5.2	0.0	0.0
Roseburg	510	9	57	29.47	30.02	.00	65.1	+2.2	101	11	81	43	22	49	47	55	45	61			1.56	+0.5	6	1,857	n.	16	sw.	26	22	6	2	1.9	0.0	0.0
Middle Pacific Coast Region.							**66.0**	**+2.8**												**61**	**0.37**	**−0.5**										**2.6**		
Eureka	62	73	89	29.96	30.03	+.02	56.0	+1.1	75	10	61	45	28	51	22	53	52	88			0.37	−0.7	3	3,263	n.	30	nw.	7	10	10	10	5.3	0.0	0.0
Point Reyes	490	7	18	29.40	29.91		56.2	+0.1	79	8	61	49	29	52	25						0.02		1	14,619	nw.	57	nw.	27	12	4	14	5.6	0.0	0.0
Red Bluff	332	50	56	29.52	29.87	−.06	77.4	+4.3	109	10	93	53	24	61	41	59	44	34			0.00	−0.8	0	3,215	se.	21	n.	8	30	0	0	0.5	0.0	0.0
Sacramento	69	106	117	29.80	29.88	−.01	75.6	+6.3	104	10	92	52	29	59	40	59	46	43			0.00	−0.4	0	4,406	se.	20	sw.	3	29	1	0	0.3	0.0	0.0
San Francisco	155	208	243	29.76	29.93	−.01	63.3	+2.4	91	8	72	52	30	55	31	56	53	79			T.	−0.3	0	5,959	sw.	29	w.	5	21	8	1	2.1	0.0	0.0
San Jose	141	12	110	29.78	29.92		67.5	+2.8	96	9	84	43	28	51	43						0.00	−0.3	0	3,173	nw.	20	n.	4	23	7	0	1.7	0.0	0.0
South Pacific Coast Region.							**72.3**	**+4.3**												**63**	**T.**	**−0.2**										**1.5**		
Fresno	327	89	98	29.52	29.86	−.01	79.1	+4.8	105	11	96	52	29	62	39	59	43	34			0.00	−0.3	0	4,836	nw.	20	nw.	25	30	0	0	0.2	0.0	0.0
Los Angeles	338	159	191	29.54	29.89	−.01	73.1	+4.1	102	17	84	57	5	62	35	62	58	68			0.00	−0.1	0	3,435	w.	14	w.	7	24	6	0	1.5	0.0	0.0
San Diego	87	62	70	29.78	29.87	−.02	70.0	+2.9	92	17	76	58	30	64	24	64	62	82			0.00	−0.1	0	4,343	nw.	23	nw.	30	22	6	2	2.6	0.0	0.0
San Luis Obispo	201	32	40	29.71	29.92	−.02	67.0	+5.5	96	16	82	44	29	52	44	56	51	68			T.	−0.4	0	2,280	n.	14	nw.	26	27	3	0	1.7	0.0	0.0
West Indies.																																		
San Juan, P. R.	82	9	54	29.87	29.95		79.7		88	18	84	73	26	75	14						6.32	−0.5	21	8,292	e.	39	e.	25	5	15	10	6.0	0.0	0.0
Panama Canal.																																		
Balboa Heights	118	7	97	29.72	29.84	.00	79.6	−0.2	90	6	85	71	12	74	16	75	74	87			8.18	+0.4	19	3,886	nw.	38	ne.	12	2	9	19	7.6	0.0	0.0
Colon	36	7	97	29.80	29.84	−.01	80.8	+0.7	90	26	87	73	8	75	16	76	75	86			12.73	+0.2	23	4,565	s.	32	nw.	7	0	8	22	8.4	0.0	0.0
Alaska.																																		
Juneau	80	11	54	29.75	29.84		49.0		64	10	54	34	1	44	23	46	44	88			10.32		23	4,897	s.	33	se.	24	3	2	25	8.6	0.0	0.0

TABLE 2.—*Data furnished by the Canadian Meteorological Service, September, 1922.*

Stations.	Altitude above mean sea level, Jan. 1, 1919.	Pressure.			Temperature of the air.						Precipitation.		
		Station reduced to mean of 24 hours.	Sea level reduced to mean of 24 hours.	Departure from normal.	Mean max.+ mean min.÷2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Feet.	*In.*	*In.*	*In.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*In.*	*In.*	*In.*
St. Johns, N. F.	125												
Sydney, C. B. I.	48	30.02	30.07	+0.06	57.0	+0.5	66.4	42.6	77	35	4.14	+0.43	0.0
Halifax, N. S.	88	29.98	30.08	+.04	56.6	−1.0	65.8	47.5	76	32	3.35	−0.36	0.0
Yarmouth, N. S.	65	30.02	30.09	+.04	54.6	−1.5	62.9	46.4	73	32	4.30	+0.85	0.0
Charlottetown, P. E. I.	38												
Chatham, N. B.	28	30.00	30.03	+.03	55.5	+0.1	66.5	44.5	82	25	1.22	−1.49	0.0
Father Point, Que.	20	30.00	30.02	+.04	48.2	−2.2	57.7	38.7	80	24	0.84	−2.29	0.0
Quebec, Que.	296	29.76	30.08	+.07	58.1	+3.0	68.0	48.2	86	30	0.84	−2.83	0.0
Montreal, Que.	187	29.87	30.07	+.03	60.6	+2.2	69.4	51.9	84	36	1.24	−2.06	0.0
Stonecliffe, Ont.	489												
Ottawa, Ont.	236	29.83	30.09	+.05	62.8	+5.4	75.7	49.9	90	30	1.51	−1.18	0.0
Kingston, Ont.	285	29.79	30.10	+.06	62.9	+2.9	71.3	54.6	84	34	1.49	−1.31	0.0
Toronto, Ont.	379	29.70	30.10	+.04	63.5	+4.5	73.6	53.4	93	35	2.98	−0.27	0.0
Cochrane, Ont.	930												
White River, Ont.	1,244	28.74	30.05	+.07	51.7	+1.4	67.2	36.2	83	20	0.47	−2.30	0.0
Port Stanley, Ont.	592	29.49	30.13	+.07	62.0	+2.5	71.4	52.7	83	34	5.05	+2.32	0.0
Southampton, Ont.	656												
Parry Sound, Ont.	688	29.40	30.08	+.05	59.6	+3.6	70.7	48.6	83	31	1.16	−2.51	0.0
Port Arthur, Ont.	644	29.35	30.06	+.08	55.7	+3.5	64.9	46.5	84	33	1.91	−1.57	0.0
Winnipeg, Man.	760	29.16	29.99	+.05	57.6	+5.1	68.1	47.1	84	32	3.01	+0.98	0.0
Minnedosa, Man.	1,690	28.18	29.98	+.04	56.3	+5.8	68.7	44.0	84	32	2.10	+0.74	0.0
Le Pas, Man.	860												
Qu'Appelle, Sask.	2,115	27.69	29.92	.00	56.7	+5.6	70.5	43.0	90	26	0.83	−0.50	0.0
Medicine Hat, Alb.	2,144	27.60	29.83	−.09	61.2	+6.2	75.0	47.4	93	37	1.45	+0.27	0.0
Moose Jaw, Sask.	1,759												
Swift Current, Sask.	2,392	27.37	29.96	+.04	58.9	+5.8	75.0	42.8	95	26	0.27	−0.95	0.0
Calgary, Alb.	3,428												
Banff, Alb.	4,521	25.37	29.89	−.04	51.3	+5.5	63.8	38.7	75	28	0.98	−0.35	0.0
Edmonton, Alb	2,150	25.57	29.83	−.07	53.6	+4.3	68.3	39.0	85	28	0.77	−0.56	0.0
Prince Albert, Sask.	1,450	28.37	29.94	+.04	54.5	+6.1	68.1	40.9	90	28	0.99	−0.29	0.0
Battleford, Sask.	1,592	28.16	29.89	−.01	56.5	+4.7	71.8	41.1	90	30	0.43	−0.83	0.0
Kamloops, B. C.	1,262												
Victoria, B. C.	230	29.73	29.98	−.03	57.1	+2.3	63.9	50.3	79	46	1.78	−0.38	0.0

LATE REPORTS.—AUGUST, 1922.

Medicine Hat, Alb.	2,144	27.60	29.80	−0.12	70.4	+4.7	84.8	56.1	99	44	1.08	−0.59	0.0
Banff, Alb.	4,521	25.42	29.91	0.00	58.0	+1.7	73.2	42.9	88	34	2.24	−0.29	0.0
Edmonston, Alb.	2,150	27.62	29.85	−.07	62.4	+3.6	76.8	48.1	93	36	3.50	+1.37	0.0
Kamloops, B. C.	1,262	28.69	29.95	+.04	67.7	−0.9	80.4	55.1	96	48	1.36	+0.27	0.0
Barkerville, B. C.	4,180	25.70	29.97	+.07	54.4	−1.9	66.2	42.6	74	35	1.78	−1.32	0.0
Hamilton, Ber.	151	30.03	30.19	+.09	79.5	−0.1	85.4	73.6	88	68	3.87	−2.21	0.0

SEISMOLOGICAL REPORTS FOR SEPTEMBER, 1922.

W. J. HUMPHREYS, Professor in Charge.

[Weather Bureau, Washington, November 3, 1922.]

TABLE 1.—*Noninstrumental earthquake reports, September, 1922.*

Day.	Approximate time, Greenwich civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
1922.	*H. m.*	CALIFORNIA.	° ′	° ′			*Sec.*			
Sept. 4	10 15	Paso Robles	35 40	120 15	4	1	3	None	Felt by many	Anna Z. Campbell.
5	9 05	San Luis Obispo	35 18	120 39	5	2	1,5	....do	....do	J. E. Hissong.
18	11 55	Eureka	40 48	124 10	2	1	2	....do	Felt by several	L. B. Cooper.
		MAINE.								
4	6 00	North Perry	45 00	67 00	2	1	3	Rumbling	....do	Robert Goulding.

TABLE 2.—*Instrumental seismological reports, September, 1922.*

Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.

[For significance of symbols and description of stations, see REVIEW for January, 1922.]

ALASKA. *U. S. C. & G. S. Magnetic Observatory, Sitka.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 1	.....	O.....	19 15 51	.....	.....	.....	8,700	
		e_E.....	19 33 27	.....	.....	.....	.....	
		e_N.....	19 31 03	.....	.....	.....	.....	
		S_E.....	19 37 38	.....	.....	.....	.....	
		S_N.....	19 37 43	.....	.....	.....	.....	
		PS_N?..	19 38 33	.....	.....	.....	.....	
		$SR1_E$..	19 43 02	.....	.....	.....	.....	
		$SR2_N$..	19 46 57	.....	.....	.....	.....	
		e_E.....	19 52 59	.....	.....	.....	.....	
		e_N.....	19 49 07	.....	.....	.....	.....	
		$L1_E$....	19 58 21	24	.....	.....	.....	
		$L2_E$....	20 04 31	.....	.....	.....	.....	
		$L1_N$....	20 02 35	24	.....	.....	.....	
		$L2_N$....	20 15 48	17	.....	.....	.....	
		M_E.....	20 05 14	18	*300	.....	.....	
		M_N.....	20 16 08	17	.....	*200	.....	
		C_E.....	20 13 ..	.....	.....	.....	.....	
		C_N.....	20 19 ..	.....	.....	.....	.....	
		F_E.....	20 43 ..	.....	.....	.....	.....	
		F_N.....	20 48 ..	.....	.....	.....	.....	
3	.....	i_E.....	3 32 25	.....	.....	.....	.....	Local. Recorded on the D and H variometers.
		e_N.....	3 32 29	.....	.....	.....	.....	
		M_E.....	3 32 37	2	40	.....	.....	
		M_N.....	3 32 41	.....	.....	40	.....	
		F_E.....	3 36 20	.....	.....	.....	.....	
		F_N.....	3 33 38*	.....	.....	.....	.....	
14	.....	e.....	20 14 54	.....	.....	.....	.....	Record obscured by wind tremors.
		M_E.....	20 18 21	17	*100	.....	.....	
		M_N.....	20 18 48	17	.....	*100	.....	
		F_E.....	20 33 ..	.....	.....	.....	.....	
		F_N.....	20 29 ..	.....	.....	.....	.....	

* Trace amplitude.

Periods of pendulums: E. 22.1 sec.; N. 18.2 sec.; multiplication, 10:1.

ARIZONA. *U. S. C. & G. S. Magnetic Observatory, Tucson.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 1	.....	e_E.....	20 00 47	.....	.....	.....	.....	Preliminary phases masked by wind tremors.
		L_E.....	20 07 27	27	.....	.....	.....	
		M_E.....	20 08 20	27	*100	.....	.....	
		F_E.....	20 50 ..	.....	.....	.....	.....	
9	.....	e_E.....	0 24 42	.....	.....	.....	.....	
		e_N.....	0 25 22	7	.....	.....	.....	
		M_E.....	0 25 42	8	*200	.....	.....	
		M_N.....	0 27 42	7	.....	*100	.....	
		F_E.....	0 33 ..	.....	.....	.....	.....	
		F_N.....	0 33 35	.....	.....	.....	.....	
29	.....	i.....	21 39 07	.....	.....	.....	.....	Local. Recorded on the magnetograph.
		M_E.....	21 40 01	.....	*1,000	.....	.....	
		M_N.....	21 39 21	4	.....	60	.....	
		C_E.....	21 41 01	7	.....	.....	.....	
		F.....	21 48 ..	.....	.....	.....	.....	
30	.....	i_E.....	23 35 12	.....	.....	.....	.....	F_E marked by wind tremors.
		e_N.....	23 35 03	.....	.....	.....	.....	
		M_E.....	23 35 30	.....	*300	.....	.....	
		M_N.....	23 35 30	5	.....	18	.....	
		C_E.....	23 36 45	.....	.....	.....	.....	
		C_N.....	23 37 ..	4	.....	.....	.....	
		F_N.....	23 42 ..	.....	.....	.....	.....	

* Trace amplitude.

CALIFORNIA. *Theosophical University, Point Loma.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 1	.....	.....	.....	.....	100	100	.....	Tremors during preceding 24 hours.
3	.....	.....	.....	.....	50	50	.....	
4	.....	.....	.....	.....	100	100	.....	
5	.....	.....	.....	.....	100	150	.....	
6	.....	.....	.....	.....	50	50	.....	
10	.....	.....	.....	.....	100	100	.....	
11	.....	.....	.....	.....	50	50	.....	
14	.....	.....	.....	.....	50	100	.....	
21	.....	.....	.....	.....	50	50	.....	
22	.....	.....	.....	.....	50	50	.....	
24	.....	.....	.....	.....	50	100	.....	
30	.....	.....	.....	.....	200	300	.....	

COLORADO. *Regis College, Denver.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 29	.....	L.....	21 40 ..	5-6	.....	.....	.....	No P waves visible; amplitude, *1,000 to *2,000.
		C_E.....	21 46 ..	.....	.....	.....	.....	
		C_N.....	21 50 ..	.....	.....	.....	.....	
		F_E.....	21 50 ..	.....	.....	.....	.....	
		F_N.....	21 56 ..	.....	.....	.....	.....	
30	.....	L.....	23 44 ..	2-3	*3,000	*2,000	.....	No P visible.
		C_E.....	23 45 ..	.....	.....	.....	.....	
		C_N.....	23 46 ..	.....	.....	.....	.....	
		F_E.....	23 46 ..	.....	.....	.....	.....	
		F_N.....	23 47 ..	.....	.....	.....	.....	

* Trace amplitude.

No quakes recorded during July and August.

DISTRICT OF COLUMBIA. *U. S. Weather Bureau, Washington.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 1	.....	P.....	19 36 44	.....	.....	.....	.....	
		S?.....	19 46 30	.....	.....	.....	.....	
		L?.....	20 00 50	22	.....	.....	.....	
		L.....	20 23 ..	.....	.....	.....	.....	
		F.....	21 *ca.*	.....	.....	.....	.....	
3	.....	e.....	3 53 48	.....	.....	.....	.....	
		F.....	3 57 *ca.*	.....	.....	.....	.....	
4	.....	P.....	17 12 13	.....	.....	.....	5,700	
		S.....	17 19 34	.....	.....	.....	.....	
		F.....	19 35 *ca.*	.....	.....	.....	.....	
9	.....	e.....	0 36 07	.....	.....	.....	.....	
		F.....	0 40 ..	.....	.....	.....	.....	
14	.....	eL.....	20 07 ..	28	.....	.....	.....	
		L.....	20 35 ..	20	.....	.....	.....	
		L.....	20 43 ..	18	.....	.....	.....	
		F.....	21 10 ..	.....	.....	.....	.....	
16	.....	eL.....	23 50 ..	.....	.....	.....	.....	
		F.....	23 58 ..	.....	.....	.....	.....	
17	.....	eL.....	8 35 ..	.....	.....	.....	.....	
		F.....	8 45 ..	.....	.....	.....	.....	
29	.....	P?.....	21 34 43	.....	.....	.....	.....	
		S.....	21 41 42	.....	.....	.....	.....	
		F.....	22 20 *ca.*	.....	.....	.....	.....	
30	.....	e.....	23 46 49	.....	.....	.....	.....	
		F.....	23 58 ..	.....	.....	.....	.....	

HAWAII. *U. S. C. & G. S. Magnetic Observatory, Honolulu.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 1	.....	O.....	19 15 54	.....	.....	.....	8,360	Maximum N occurs during S at 19:37:10.
		P_N.....	19 27 34	.....	.....	.....	.....	
		S_N.....	19 37 12	12	.....	92	.....	E record masked by overlapping of traces.
		$SR1_N$..	19 41 50	.....	.....	.....	.....	
		$SR2_N$..	19 45 20	29	.....	.....	.....	
		L_E.....	19 50 00	32	.....	.....	.....	
		eL_N....	19 49 52	28	.....	.....	.....	
		M_E.....	19 50 36	19	134	.....	.....	
		M_N.....	19 52 02	21	.....	61	.....	
		F_E.....	22 08 ..	.....	.....	.....	.....	
		F_N.....	21 19 ..	.....	.....	.....	.....	
2	.....	e_E.....	20 37 13	.....	.....	.....	.....	Barely perceptible on E only.
		F_E.....	20 40 10	.....	.....	.....	.....	
6	.....	e_E.....	1 51 05	.....	.....	.....	.....	Do.
		F_E.....	1 52 20	.....	.....	.....	.....	
6	.....	e_E.....	22 54 ..	.....	.....	.....	.....	Do.
		F_E.....	23 01 ..	.....	.....	.....	.....	
9	.....	e.....	0 37 56	.....	.....	.....	.....	
		M_E.....	0 39 30	9	11	.....	.....	
		M_N.....	0 39 41	9	.....	9	.....	
		C_E.....	0 40 15	.....	.....	.....	.....	
		C_N.....	0 40 32	.....	.....	.....	.....	
		F.....	0 48 ..	.....	.....	.....	.....	

TABLE 2.—*Instrumental seismological reports, September, 1922*—Continued.

HAWAII. *U. S. C. & G. S. Magnetic Observatory, Honolulu*—Contd.

1922.			H. m. s.	Sec.	μ	μ	Km.	
Sept. 11	.....	e_E	12 56 ..	.....	.....	.....	.....	Barely perceptible on E only.
		F_E	13 02 ..	.....	.....	.....	.....	
11	.....	e_E	15 24 ..	.....	.....	.....	.....	Do.
		F_E	15 28 ..	.....	.....	.....	.....	
12	.....	e_E	11 52 05	.....	.....	.....	.....	N trace amplitude 1.5 mm.
		e_N	11 54 22	.....	.....	.....	.....	
		M_E	11 56 12	9	9	.....	.....	
		M_N	11 56 09	.....	.....	.....	.....	
		F	12 12 ..	.....	.....	.....	.....	
14	.....	O	19 44 ..	.....	.....	.....	5,300	E record masked by overlapping of traces. Interpretation doubtful. Maximum trace amplitude 1.3 mm.
		iP_N	19 52 40	.....	.....	.....	.....	
		e_N	20 01 10	.....	.....	.....	.....	
		L_N?	20 07 15	.....	.....	.....	.....	
		M_N	20 02 45	.....	.....	.....	.....	
		F	20 50 ..	.....	.....	.....	.....	
16	.....	P	23 05 35	.....	.....	.....	.....	May be interpreted as either 8,200 km. or 5,200 km. distant.
		e_E	23 17 25	.....	.....	.....	.....	
		e_N	23 15 02	.....	.....	.....	.....	
		L_E?	23 21 25	.....	.....	.....	.....	
		L_N?	23 30 02	.....	.....	.....	.....	
		M_E	23 32 30	16	5	.....	.....	
		M_N	23 16 50	30	.....	13	.....	
		F_E	23 50 ..	.....	.....	.....	.....	
		F_N	23 43 ..	.....	.....	.....	.....	
17	.....	O	7 35 ..	.....	.....	.....	5,200	Interpretation doubtful.
		P	7 43 58	.....	.....	.....	.....	
		L_E?	7 57 25	.....	.....	.....	.....	
		eL_N?	7 58 00	.....	.....	.....	.....	
		M_E	8 00 40	21	15	.....	.....	
		M_N	8 00 30	25	.....	6	.....	
		F_E	8 52...	.....	.....	.....	.....	
		F_N	8 28 ..	.....	.....	.....	.....	
17	.....	O	10 12 ..	.....	.....	.....	5,200	
		P	10 20 19	.....	.....	.....	.....	
		$SR1_N$	10 30 18	.....	.....	.....	.....	
		eL_E	10 36 00	.....	.....	.....	.....	
		L_N	10 34 15	21	.....	.....	.....	
		M_E	10 42 42	18	23	.....	.....	
		M_N	10 45 35	20	.....	8	.....	
		C_E	10 50 ..	.....	.....	.....	.....	
		F_E	11 14 ..	.....	.....	.....	.....	
		F_N	11 03 ..	.....	.....	.....	.....	
18	.....	e_E	12 08 27	.....	.....	.....	.....	Maximum trace amplitude on E, 0.5 mm.
		e_N	12 08 40	.....	.....	.....	.....	
		M_E	12 10 18	.....	.....	.....	.....	
		M_N	12 10 30	7	.....	3	.....	
		F	12 17 ..	.....	.....	.....	.....	
30	.....	O	8 33 ..	.....	.....	.....	3,000	Preliminary phases very weak. L_N impossible to separate from S_N.
		e_N	8 30 25	.....	.....	.....	.....	
		PS_N?	8 32 30	.....	.....	.....	.....	
		S_E	8 33 00	.....	.....	.....	.....	
		S_N	8 33 03	.....	.....	.....	.....	
		L_E	8 35 32	.....	.....	.....	.....	
		M_E	8 38 30	6	23	.....	.....	
		M_N	8 38 19	6	.....	18	.....	
		F_E	9 21 ..	.....	.....	.....	.....	
		F_N	9 17 ..	.....	.....	.....	.....	

ILLINOIS. *U. S. Weather Bureau, Chicago.*

1922.			H. m. s.	Sec.	μ	μ	Km.	
Sept. 1	.....	P	19 34 56	.....	.....	.....	8,400	
		S	19 44 35	.....	.....	.....	.....	
		L	19 58 11	22	.....	.....	.....	
		L	20 22 ..	20	.....	.....	.....	
		F	22 10 ca.	.....	.....	.....	.....	
3	.....	e	3 49 54	.....	.....	.....	.....	
		F	4 ca.	.....	.....	.....	.....	
4	.....	P	17 14 35	.....	.....	.....	.....	
		S	17 19 28	.....	.....	.....	.....	
		SR1?	17 21 23	.....	.....	.....	.....	
		F	17 50 ca.	.....	.....	.....	.....	
4	.....	eL	18 51 ..	.....	.....	.....	.....	
		F	19 25 ca.	.....	.....	.....	.....	
9	.....	P	0 28 36	.....	.....	.....	.....	
		S	0 32 29	.....	.....	.....	.....	
		F	1 ca.	.....	.....	.....	.....	
11	.....	eL	15 48 ..	20	.....	.....	.....	
		F	17 05 ca.	.....	.....	.....	.....	
12	.....	P	11 54 00	.....	.....	.....	5,100	
		L	12 07 45	18	.....	.....	.....	
		F	.....	.....	.....	.....	.....	Off sheet.
14	.....	P?	19 46 30	.....	.....	.....	.....	
		L	20 20 ..	35	.....	.....	.....	
		L	20 33 ..	18	.....	.....	.....	
		L	20 45 ..	15	.....	.....	.....	
		F	22 30 ca.	.....	.....	.....	.....	

ILLINOIS. *N. S. Weather Bureau, Chicago*—Continued.

1922.			H. m. s.	Sec.	μ	μ	Km.	
Sept. 16	.....	e	23 27 28	.....	.....	.....	.....	
		L	23 38 40	.....	.....	.....	.....	
		L	23 44 ..	20	.....	.....	.....	
		L	23 56 ..	18	.....	.....	.....	
17	.....	F	0 40 ..	.....	.....	.....	.....	
17	.....	eL	8 14 ..	.....	.....	.....	.....	
		L	8 20 ..	20	.....	.....	.....	
		L	8 28 ..	15	.....	.....	.....	
		F	9 30 ca.	.....	.....	.....	.....	
17	.....	P?	10 27 13	.....	.....	.....	.....	
		L	10 51 ..	30	.....	.....	.....	
		L	10 58 ..	22	.....	.....	.....	
		F	12 ca.	.....	.....	.....	.....	
18	.....	e	12 08 20	.....	.....	.....	.....	
		F	12 20 ca.	.....	.....	.....	.....	
22	.....	P?	21 38 00	.....	.....	.....	.....	
		L	21 44 ..	.....	.....	.....	.....	
		F	22 05 ca.	.....	.....	.....	.....	
29	.....	P?	19 29 55	.....	.....	.....	.....	
		eL	19 36 ..	.....	.....	.....	.....	
		L	19 40 ..	18	.....	.....	.....	
		F	20 ca.	.....	.....	.....	.....	
29	.....	P	21 35 12	.....	.....	.....	3,000	L not visible.
		S	21 39 50	.....	.....	.....	.....	
		F	22 35 ..	.....	.....	.....	.....	
30	.....	e	23 42 04	.....	.....	.....	.....	
		S?	23 42 27	.....	.....	.....	.....	
		F	23 56 ca.	.....	.....	.....	.....	

MARYLAND. *U. S. C. & G. S. Observatory, Cheltenham.*

1922.			H. m. s.	Sec.	μ	μ	Km.	
Sept. 1	.....	*O*	19 16 34	.....	.....	.....	12,600	Phases poorly defined.
		$PR1_E$	19 36 00	.....	.....	.....	.....	
		e_N	19 41 01	.....	.....	.....	.....	
		eS_E	19 44 22	.....	.....	.....	.....	
		eS_N	19 45 32	.....	.....	.....	.....	
		PS_N?	19 46 46	7	.....	.....	.....	
		$SR1_E$	19 51 58	.....	.....	.....	.....	
		$SR1_N$	19 52 58	40	.....	.....	.....	
		e_E	19 56 38	.....	.....	.....	.....	
		Le	20 11 50	35	.....	.....	.....	
		$L1_N$	20 12 ..	.....	.....	.....	.....	
		$L2_N$	20 22 09	25	.....	.....	.....	
		M_E	20 12 20	35	*100	.....	.....	
		M_N	20 27 56	21	.....	*100	.....	
		F	20 51 ..	.....	.....	.....	.....	

* Trace amplitude.

NEW YORK. *Fordham University, New York.*

1922			H. m. s.	Sec.	μ	μ	Km.	
Sept. 2	.....	.....	.....	.....	.....	.....	.....	Slight quake. Station put into operation near end of month; no time correction.

CANAL ZONE. *Panama Canal, Balboa Heights.*

1922			H. m. s.	Sec.	μ	μ	Km.	
Sept. 15	.....	.....	.....	.....	.....	.....	.....	Very slight tremor from 19:54 to 20:03; distance and direction unknown, probably local.

VERMONT. *U. S. Weather Bureau, Northfield.*

1922			H. m. s.	Sec.	μ	μ	Km.	
Sept. 1	.....	e	19 39 ..	.....	.....	.....	.....	
		S	19 44 55	.....	.....	.....	.....	
		eL	20 17 ..	.....	.....	.....	.....	
		L	20 21 ..	22	.....	.....	.....	
		F	20 05 ca.	.....	.....	.....	.....	
11	.....	eL	15 58 ..	.....	.....	.....	.....	
		F	16 02 ..	.....	.....	.....	.....	

TABLE 2.—*Instrumental seismological reports, September, 1922*—Continued.

PORTO RICO. *U. S. C. & G. S. Magnetic Observatory, Vieques.*

1922			H. m. s.	Sec.	μ	μ	Km.	
Sept. 1	.....	L_N	20 32 22	.....	.....	.....	.....	L_N corresponds to $L2_N$ phase at Cheltenham; no record on E.
		M_N	20 34 22	27	.....	*200	.....	
		F_N	20 41 ..	.....	.....	.....	.....	

* Trace amplitude.

CANADA. *Dominion Observatory, Ottawa.*

1922			H. m. s.	Sec.	μ	μ	Km.	
Sept. 1	.....	O	19 23 26	.....	.....	.....	8,180	
		P	19 34 56	.....	.....	.....	.....	
		S	19 44 25	.....	.....	.....	.....	
		eL	19 58 18	.....	.....	.....	.....	
		L	20 05 ..	40	.....	.....	.....	
		L	20 14 ..	26	.....	.....	.....	
		L	20 24 ..	18	.....	.....	.....	
		L	20 34 ..	15	.....	.....	.....	
		L	20 40 ..	13	.....	.....	.....	
		L	20 42 ..	18	.....	.....	.....	
		L	21 00 ..	18	.....	.....	.....	
		L	21 15 ..	16	.....	.....	.....	
		F	22 ca.	.....	.....	.....	.....	
3	.....	e_N	3 51 39	.....	.....	.....	.....	
		eL	3 54 ..	.....	.....	.....	.....	
		F	4 00 ..	.....	.....	.....	.....	
4	.....	i	17 13 00	.....	.....	.....	.....	
		i	17 15 00	.....	.....	.....	.....	
		i	17 20 00	.....	.....	.....	.....	
		i	17 21 40	.....	.....	.....	.....	
		F	17 45 ..	.....	.....	.....	.....	
4	.....	L_E	18 53 *to*	.....	.....	.....	.....	
			19 10 ..	.....	.....	.....	.....	
11	.....	eL_E	(15 48)	.....	.....	.....	.....	
		L	15 54 ..	.....	.....	.....	.....	
		L	15 58 ..	20	.....	.....	.....	
		F	16 15 ca.	.....	.....	.....	.....	
12	.....	e	11 54 37	.....	.....	.....	.....	
		eL	12 02 ..	.....	.....	.....	.....	
		L	12 09 ..	19	.....	.....	.....	
		L	12 19 ..	15	.....	.....	.....	
		L	12 26 ..	13	.....	.....	.....	
		F	12 50 ..	.....	.....	.....	.....	
14	.....	e_E	19 48 24	.....	.....	.....	.....	Time uncertain; time signals not working properly. P very small; L well marked.
		e	19 53 36	.....	.....	.....	.....	
		eL_E	20 01 ..	.....	.....	.....	.....	
		L_E	20 13 18	.....	.....	.....	.....	
		L_E	20 16 ..	40	.....	.....	.....	
		L_E	20 21 ..	30	.....	.....	.....	
		L	20 24 30	24	.....	.....	.....	
		L	20 29 ..	20	.....	.....	.....	
		L	20 32 ..	18	.....	.....	.....	
		L	20 37 ..	16	.....	.....	.....	
		L	20 43 ..	16	.....	.....	.....	
		L	20 51 ..	16	.....	.....	.....	
		L	21 15 ..	18	.....	.....	.....	
		F	21 43 ca.	.....	.....	.....	.....	
16	.....	$e?_M$	23 14 ..	.....	.....	.....	.....	Subscript M refers to Milne-Shaw N-S. component.
		$e?_M$	23 25 ..	.....	.....	.....	.....	
		e	23 28 ..	.....	.....	.....	.....	
		eL_M	23 33 ..	.....	.....	.....	.....	
		L	23 41 ..	24	.....	.....	.....	
		L	23 45 ..	20	.....	.....	.....	
		L	23 55 ..	14	.....	.....	.....	
		F	0 30 ..	.....	.....	.....	.....	
17	.....	e	8 12 ..	.....	.....	.....	.....	
		eL	8 20 ..	28	.....	.....	.....	
		L	8 23 ..	22	.....	.....	.....	
		L	8 25 ..	18	.....	.....	.....	
		L	8 32 ..	12	.....	.....	.....	
		L	8 36 ..	18	.....	.....	.....	
		L	8 51 ..	18	.....	.....	.....	
		L_M	9 05 ..	.....	.....	.....	.....	
		F	9 10 ca.	.....	.....	.....	.....	
17	.....	e	10 25 42	.....	.....	.....	.....	
		e	10 27 30	.....	.....	.....	.....	
		e	10 41 ..	.....	.....	.....	.....	
		eL	10 44 ..	.....	.....	.....	.....	
		L	10 56 ..	26	.....	.....	.....	
		L	11 00 ..	20	.....	.....	.....	
		L	11 04 ..	16	.....	.....	.....	
		L	11 08 ..	14	.....	.....	.....	
		F	12 00 ca.	.....	.....	.....	.....	
29	.....	$eL?_E$	19 29 ..	.....	.....	.....	.....	Irregular, may not be seismic.
		Le_E	19 33 30	.....	.....	.....	.....	
		F	19 50 ca.	.....	.....	.....	.....	
29	.....	$P?_{NMV}$	21 42 00	.....	.....	.....	.....	Irregular waves; certainly seismic.
		i_M	21 49 45	.....	.....	.....	.....	
		eL_E	21 51 ..	8	.....	.....	.....	
		L	21 52 30	.....	.....	.....	.....	
		F	22 30 ..	.....	.....	.....	.....	
30	.....	i_M	23 46 51	.....	.....	.....	.....	Irregular sharp wavelets of small amplitude.
		F	23 54 ..	.....	.....	.....	.....	

CANADA. *Dominion meteorological service, Toronto.*

1922.			H. m. s.	Sec.	μ	μ	Km.	
Sept. 1	.....	P?	19 34 54	.....	.....	.....	8,550	
		i?	19 36 42	.....	.....	.....	.....	
		i	19 40 00	.....	.....	.....	.....	
		S	19 44 42	.....	.....	.....	.....	
		iI?	20 02 06	.....	.....	.....	.....	
		iL	20 21 00	.....	.....	.....	.....	
		M	20 23 36	.....	*1,500	.....	.....	
		eL	20 46 42	.....	.....	.....	.....	
		eL	21 14 54	.....	.....	.....	.....	
		F	.....	.....	.....	.....	.....	
12	.....	L	11 56 36	.....	.....	.....	.....	
		eL	12 13 12	.....	*200	.....	.....	
		F	.....	.....	.....	.....	.....	
14	.....	e	?19 55 12	.....	.....	.....	.....	Early L waves interfered with by inspection of instrument.
		L	20 36 24	.....	.....	.....	.....	
		eL	20 43 48	.....	.....	.....	.....	
		F	.....	.....	.....	.....	.....	
16	.....	eL	23 48 12	.....	.....	.....	.....	
		M	23 50 30	.....	*300	.....	.....	
		eL	23 58 48	.....	.....	.....	.....	
		F?	0 04 30	.....	.....	.....	.....	
17	.....	L	8 26 24	.....	.....	.....	.....	
		L	8 29 36	.....	.....	.....	.....	
		eL	8 58 42	.....	*200	.....	.....	
		F	9 07 12	.....	.....	.....	.....	
17	.....	L	11 02 48	.....	.....	.....	.....	
		L	11 10 54	.....	.....	.....	.....	
		M	11 12 54	.....	*200	.....	.....	
		eL	11 20 54	.....	.....	.....	.....	
		F	11 38 54?	.....	.....	.....	.....	
29	.....	L	21 16 48	.....	.....	.....	.....	Irregular waves 19h. 29m. possibly not seismic. Micros going on.
		L	21 43 18	.....	.....	.....	.....	
		eL	21 44 06	.....	.....	.....	.....	
		M	21 45 24	.....	*300	.....	.....	
		F	.....	.....	.....	.....	.....	

* Trace amplitude.

CANADA. *Dominion meteorological service, Victoria.*

1922.			H. m. s.	Sec.	μ	μ	Km.	
Sept. 1	.....	P	19 28 24	.....	.....	.....	.....	
		S?	19 32 52	.....	.....	.....	.....	
		L	19 38 49	.....	.....	.....	.....	
		e	19 44 56	.....	.....	.....	.....	
		eL	20 00 08	.....	.....	.....	.....	
		M	20 11 08	.....	*2,000	.....	.....	
		iL	20 13 20	.....	.....	.....	.....	
		eL	21 29 50	.....	.....	.....	.....	
		eL	21 31 32	.....	.....	.....	.....	
		F	22 14 38	.....	.....	.....	.....	
12	.....	L	11 54 23	.....	.....	.....	.....	
		M	11 58 49	.....	*200	.....	.....	
		F	12 05 46	.....	.....	.....	.....	
14	.....	P	19 54 03	.....	.....	.....	4,660	Light turned down at 20h. 08m.; early L phases lost.
		S	20 00 27	.....	.....	.....	.....	
		M	20 22 46	.....	*800	.....	.....	
		F	21 56 30	.....	.....	.....	.....	
16	.....	L	23 35 32	.....	.....	.....	.....	
		L	23 44 08	.....	.....	.....	.....	
		F	0 03 00	.....	*100	.....	.....	
17	.....	L	8 14 50	.....	.....	.....	.....	
		L	?8 23 20	.....	*100	.....	.....	
		F	8 51 00	.....	.....	.....	.....	
17	.....	L	10 44 10	.....	.....	.....	.....	
		M	10 58 03	.....	*200	.....	.....	
		F	11 16 24	.....	.....	.....	.....	
29	.....	?P	21 46 27	.....	.....	.....	.....	
		L	21 47 57	.....	.....	.....	.....	
		M	21 50 27	.....	*800	.....	.....	
		F	21 58 57	.....	.....	.....	.....	

VERTICAL.

1	.....	P	19 28 40	7	.....	.....	.....	
		M	20 13 30	15	1	.....	.....	

* Trace amplitude.

Reports for September, 1922, have not been received from the following stations:

ALABAMA, *Spring Hill College*, Mobile.

DISTRICT OF COLUMBIA, *Georgetown University*, Washington.

MASSACHUSETTS, *Harvard University*, Cambridge.

MISSOURI, *St. Louis University*, St. Louis.

NEW YORK, *Cornell University*, Ithaca.

TABLE 3.—*Late reports (instrumental).*

DISTRICT OF COLUMBIA. *Georgetown University, Washington.*

1922.			H. m. s.	Sec.	μ	μ	Km.	
June 2	.....	S.....	20 33 ..	.....	.....	.....	.....	Heavy micros; S quite certain.
		L.....	21 39 ..	.....	.....	.....	.....	
		F.....	22 20 ..	.....	.....	.....	.....	
8	.....	e.....	11 08 49	.....	.....	.....	.....	Heavy micros.
		F.....	11 15 ..	.....	.....	.....	.....	
12	.....	eP_E...	4 53 54	.....	.....	.....	.....	Heavy micros.
		eP_N...	4 54 00	.....	.....	.....	.....	
		S_E.....	4 59 04	.....	.....	.....	.....	
		iS_N...	4 59 04	.....	.....	.....	.....	
		i_E.....	5 01 43	.....	.....	.....	.....	
		eL_E...	5 04 24	6	.....	.....	.....	
		eL_N...	5 04 06	6	.....	.....	.....	
		M_E...	5 07 ..	15	*7,700	.....	.....	
		M_N....	5 04 48	8	.....	*17,200	.....	
		F.....	6 *ca.*	.....	.....	.....	.....	
12	.....	e_E.....	10 49 16	.....	.....	.....	.....	Heavy micros; no distinct M.
		e_N.....	10 49 17	.....	.....	.....	.....	
		eS_E?...	10 54 39	.....	.....	.....	.....	
		eS_N?..	10 54 39	.....	.....	.....	.....	
		eL_E...	11 01 00	13	.....	.....	.....	
		eL_N...	11 00 18	13	.....	.....	.....	
		F.....	11 56 ..	.....	.....	.....	.....	
16	.....	L_E....	12 59 *to* 13 02 ..	.....	.....	.....	.....	Heavy micros.
16	.....	e_N.....	21 12 37	.....	.....	.....	.....	Do.
		S.....	21 15 44	.....	.....	.....	.....	
		F.....	21 50 ..	.....	.....	.....	.....	
27	.....	e_N.....	15 00 32	.....	.....	.....	.....	Do.
		L_N....	15 22 ..	.....	.....	.....	.....	
		F.....	15 30 ..	.....	.....	.....	.....	
July 2	.....	eP_E...	13 45 45	.....	.....	.....	.....	
		eP_N...	13 45 34	.....	.....	.....	.....	
		S_E?...	13 52 23	.....	.....	.....	.....	
		S_N?...	13 52 21	.....	.....	.....	.....	
		eL_E...	14 00 ..	18	.....	.....	.....	
		eL_N...	14 06 24	16	.....	.....	.....	
		L_E....	14 08 ..	.....	.....	.....	.....	
		L_N....	14 10 58	.....	.....	.....	.....	
		F.....	15 15 ..	.....	.....	.....	.....	
2	.....	eP_E?..	21 27 24	.....	.....	.....	.....	
		S.....	21 29 45	.....	.....	.....	.....	
		F.....	21 40 ..	.....	.....	.....	.....	
Aug. 11	.....	eP_E...	8 31 27	.....	.....	.....	.....	Rest lost in heavy micros.
		iS.....	8 41 52	.....	.....	.....	.....	
11	.....	e_E.....	13 56 ..	.....	.....	.....	.....	Very heavy micros; no distinct M.
		e_N.....	13 56 29	.....	.....	.....	.....	
		L_E....	13 17 40	19	.....	.....	.....	
		L_N....	13 21 34	21	.....	.....	.....	
		F.....	15 *ca.*	.....	.....	.....	.....	
13	.....	P.....	0 21 16	.....	.....	.....	.....	Very heavy micros; sheets off 1h. 23*m.*, quake still on.
		iS.....	0 31 55	.....	.....	.....	.....	
		eL_N?..	0 45 18	.....	.....	.....	.....	
		L.....	0 48 ..	26	.....	.....	.....	
16	.....	eP_E...	16 08 13	.....	.....	.....	.....	Very heavy micros; no distinct M.
		iP_N...	16 08 13	.....	.....	.....	.....	
		eS.....	16 18 13	.....	.....	.....	.....	
		L_E....	16 35 28	21	.....	.....	.....	
		L_N....	16 41 38	21	.....	.....	.....	
		F.....	17 10 ..	.....	.....	.....	.....	
18	.....	e_E.....	5 29 27	.....	.....	.....	.....	Very heavy micros; NS does not show.
		F.....	5 41 ..	.....	.....	.....	.....	
29	.....	e.....	17 22 22	.....	.....	.....	.....	Rather heavy micros.
		S_N?....	17 28 51	.....	.....	.....	.....	
		F.....	18 *ca.*	.....	.....	.....	.....	
30	.....	e_N.....	22 58 49	.....	.....	.....	.....	Difficult; heavy micros.
		F.....	23 20 ..	.....	.....	.....	.....	

CANADA. *Dominion Observatory, Ottawa.*

1922.			H. m. s.	Sec.	μ	μ	Km.	
July 2	.....	*O*.....	13 35 56	.....	.....	.....	5,640	Subscript M refers to Milne-Shaw seismograph N-S comp.
		P_{MV}..	13 45 05	.....	.....	.....	.....	
		S_M....	13 52 22	.....	.....	.....	.....	
		eL_{MN}.	14 00 00	30	.....	.....	.....	
		L_E....	14 06 ..	25	.....	.....	.....	Halifax record not completely legible; indicates, however, that the waves reached Halifax before reaching Ottawa.
		L_E....	14 13 ..	25	.....	.....	.....	
		L_E....	14 20 ..	16	.....	.....	.....	
		L_E....	14 25 ..	16	.....	.....	.....	
		L_E....	14 30 ..	16	.....	.....	.....	
		L_E....	14 40 ..	14	.....	.....	.....	
		L_E....	14 50 ..	14	.....	.....	.....	
		L_E....	15 00 ..	12	.....	.....	.....	
		L_E....	15 10 ..	11	.....	.....	.....	
		L_E....	15 20 ..	10	.....	.....	.....	
		F.....	15 40 ..	.....	.....	.....	.....	
2	.....	e_M....	21 25 35	.....	.....	.....	.....	Small period oscillations, indicate short distance.
		e_M....	21 26 06	.....	.....	.....	.....	
		M.....	21 26 30	.....	.....	.....	.....	
		F.....	21 40 ..	.....	.....	.....	.....	
4	.....	e_M....	13 58 30	.....	.....	.....	.....	No record on vertical; only slight record on Bosch seismographs.
		e_M....	14 01 08	.....	.....	.....	.....	
		eL_M...	14 05 10	.....	.....	.....	.....	
		F.....	14 25 *ca.*	.....	.....	.....	.....	
5	.....	e_M....	18 52 18	.....	.....	.....	.....	
		e_M....	19 00 00	.....	.....	.....	.....	
		eL_{MV}..	19 06 30	18	.....	.....	.....	
		L_M....	19 15 ..	15	.....	.....	.....	
		L_M....	19 21 *to* 19 38 ..	12	.....	.....	.....	
		LR1?.	21 06 ..	.....	.....	.....	.....	
		F.....	21 25 ..	.....	.....	.....	.....	
10	.....	*O*.....	9 38 00	.....	.....	.....	6,380	
		P.....	9 47 53	.....	.....	.....	.....	
		S.....	9 55 50	.....	.....	.....	.....	Irregular L waves on all components.
		i.....	9 56 45	.....	.....	.....	.....	
		e_E.....	9 59 20	.....	.....	.....	.....	
		L.....	10 03 30 *to* 15 ..	.....	.....	.....	.....	
		F.....	10 30 ..	.....	.....	.....	.....	
13	.....	e_M....	5 18 55	.....	.....	.....	.....	May not be seismic; not recorded on any other seismographs except the Milne-Shaw.
		L_M....	5 58 ..	.....	.....	.....	.....	
		L_M....	6 04 *to* 6 15 ..	22	.....	.....	.....	
		L_M....	6 16 ..	19	.....	.....	.....	
		L_M....	6 21 *to* 6 28 ..	15	.....	.....	.....	
		F.....	6 39 ..	.....	.....	.....	.....	
25	.....	e.....	10 49 22	.....	.....	.....	.....	Small amplitude waves; barely discernible.
		e.....	10 52 ..	.....	.....	.....	.....	
		eL_M...	10 57 ..	.....	.....	.....	.....	
		L.....	10 58 ..	15	.....	.....	.....	
		F.....	11 25 ..	.....	.....	.....	.....	
26	.....	*O*?....	6 31 08	.....	.....	.....	1,970	
		eP.....	6 35 14	.....	.....	.....	.....	
		eS?....	6 38 37	.....	.....	.....	.....	
		eL?....	6 40 06	.....	.....	.....	.....	
		F.....	.....	.....	.....	.....	.....	Lost in micros about 7:00.
Aug. 9	.....	eL_M...	17 00 ..	.....	.....	.....	.....	No trace on other components.
		L_M....	17 02 *to* 17 07 ..	.....	.....	.....	.....	
		F.....	17 10 *ca*	.....	.....	.....	.....	
11	.....	*O*.....	(8 19 36)	.....	.....	.....	(8,360)	
		eP_{VM}..	8 31 18	.....	.....	.....	.....	
		iS.....	8 40 56	.....	.....	.....	.....	
		eL_M...	8 54 ..	.....	.....	.....	.....	
		L.....	8 55 ..	27	.....	.....	.....	
		L.....	9 00 ..	17	.....	.....	.....	
		F.....	9 45 ..	.....	.....	.....	.....	
11	.....	e_M....	13 57 45	.....	.....	.....	.....	No trace on vertical.
		L.....	14 14 ..	16	.....	.....	.....	
		L.....	14 19 ..	20	.....	.....	.....	
		L.....	14 22 ..	16	.....	.....	.....	
		L.....	14 28 ..	12	.....	.....	.....	
		F.....	14 52 ..	.....	.....	.....	.....	

TABLE 3.—*Late reports (instrumental)*—Continued.

CANADA. *Dominion Observatory, Ottawa*—Continued.

1922.			H. m. s.	Sec.	μ	μ	Km.	
Aug. 13	.....	O.....	0 09 58	.....	.....	.....	8,200	Difficult to get distance; P and S appear a few seconds different on all components.
		P_M....	0 21 30	.....	.....	.....	.....	
		S_M....	0 31 00	.....	.....	.....	.....	
		L_M....	0 45 ..	40	.....	.....	.....	
		L.....	0 47 ..	30	.....	.....	.....	
		L.....	0 52 *to* 1 05 ..	16	.....	.....	.....	
		F.....	2 15 *ca*	.....	.....	.....	.....	
16	.....	O.....	15 56 27	.....	.....	.....	7,860	
		P_M....	16 07 41	.....	.....	.....	.....	
		S_M....	16 16 54	.....	.....	.....	.....	
		L_M....	16 29 ..	40	.....	.....	.....	
		L.....	16 36 ..	31	.....	.....	.....	
		L.....	16 44 ..	20	.....	.....	.....	
		M.....	16 48 ..	.....	.....	.....	.....	
		F.....	17 50 *ca*	.....	.....	.....	.....	
8	.....	eL_M....	5 30 ..	.....	.....	.....	.....	Faint record; mostly lost in micros. Lost in micros.
		L_M....	5 31 ..	16	.....	.....	.....	
		F.....	.....	.....	.....	.....	.....	
25	.....	e.....	12 42 30	.....	.....	.....	.....	Very faint records of small amplitude; slow speed of Milne-Shaw renders it visible—lost on faster running Bosch.
		eL.....	12 48 ..	.....	.....	.....	.....	
		L_M....	13 05 *to* 13 13 ..	16	.....	.....	.....	
		F.....	Micros ..					

CANADA. *Dominion Observatory, Ottawa*—Continued.

1922.			H. m. s.	Sec.	μ	μ	Km.	
Aug. 25	.....	O.....	19 28 55	.....	.....	.....	9,200	
		P.....	19 42 18	.....	.....	.....	.....	
		S.....	19 52 38	.....	.....	.....	.....	
		L.....	(20 09)	.....	.....	.....	.....	
		L.....	20 14 ..	22	.....	.....	.....	
		L.....	20 19 ..	.....	.....	.....	.....	
		L.....	20 26 *to* 20 35 ..	14	.....	.....	.....	
		F.....	21 10 *ca*	.....	.....	.....	.....	
29	.....	e_M....	17 21 19	.....	.....	.....	.....	
		e.....	17 26 58	.....	.....	.....	.....	
		e_M....	17 31 23	.....	.....	.....	.....	
		eLe...	17 56 ..	.....	.....	.....	.....	
		L.....	18 06 ..	19	.....	.....	.....	
		L.....	18 17 ..	17	.....	.....	.....	
		F.....	18 57 *ca*	.....	.....	.....	.....	
30	.....	e_M....	22 50 45	.....	.....	.....	.....	Press reports quake at Santiago, Chile, 7:52 p. m.; can not be reconciled with this record.
		e_M....	22 54 38	.....	.....	.....	.....	
		e.....	22 57 15	.....	.....	.....	.....	
		eL.....	22 58 ..	.....	.....	.....	.....	
		L.....	23 01 ..	12	.....	.....	.....	
		F.....	23 40 *ca*	.....	.....	.....	.....	

(Inset) Departure of Monthly Mean Pressure from Normal. September, 1922.

Chart I. Tracks of Centers of Anticyclones, September, 1922. (Inset) **Departure of Monthly Mean Pressure from Normal.**

(Plotted by Wilfred P. Day.)

Chart II. Tracks of Centers of Cyclones, September, 1922. (Inset) Change in Mean Pressure from Preceding Month.

(Plotted by Wilfred P. Day.)

Chart III. Departure (°F.) of the Mean Temperature from the Normal, September, 1922.

Chart IV. Total Precipitation, Inches, September, 1922. (Inset) **Departure of Precipitation from Normal.**

Chart V. Percentage of Clear Sky between Sunrise and Sunset, September, 1922.

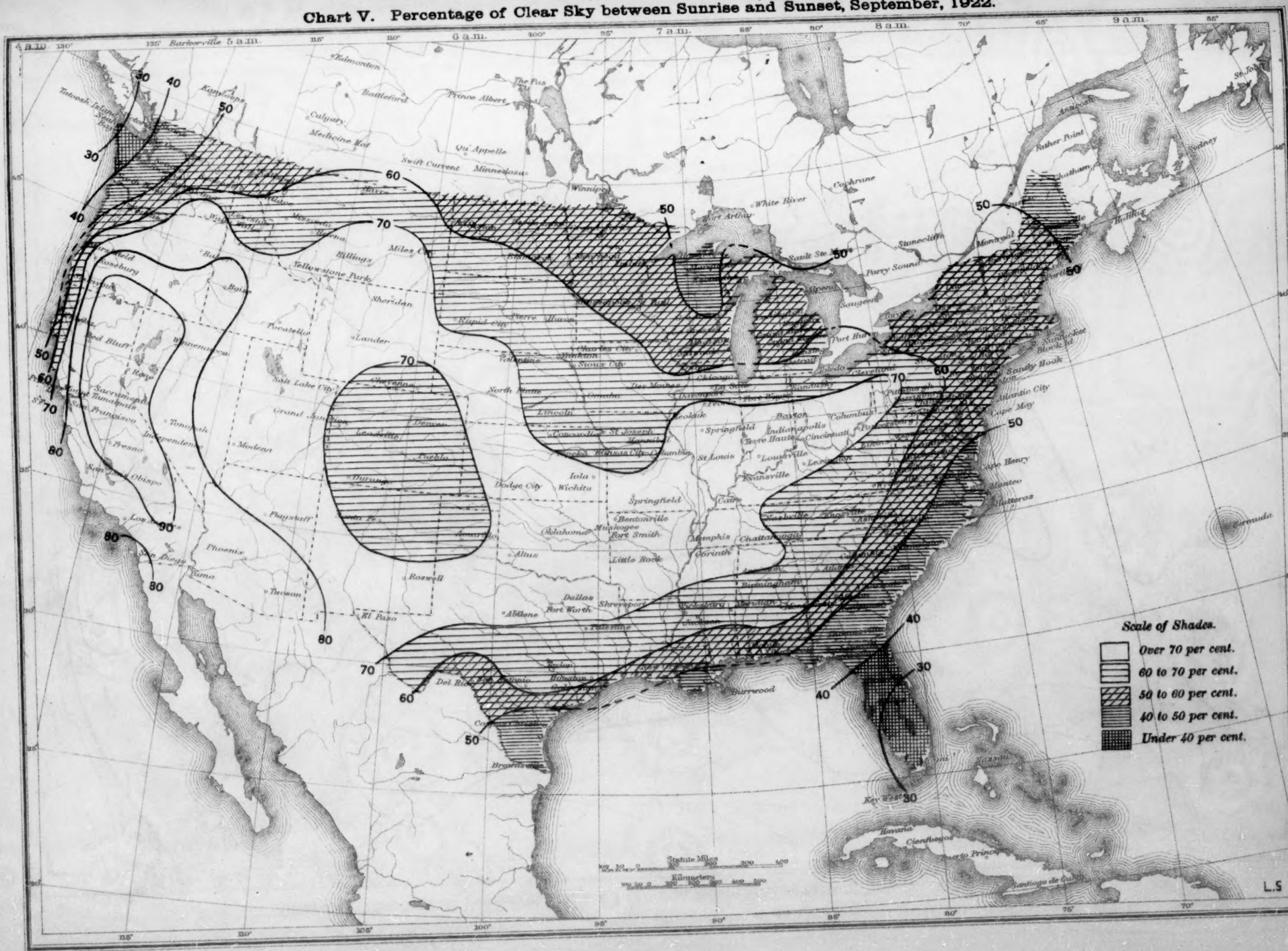


Chart VI. Isobars at Sea-level and Isotherms at Surface; Prevailing Winds, September, 1922.

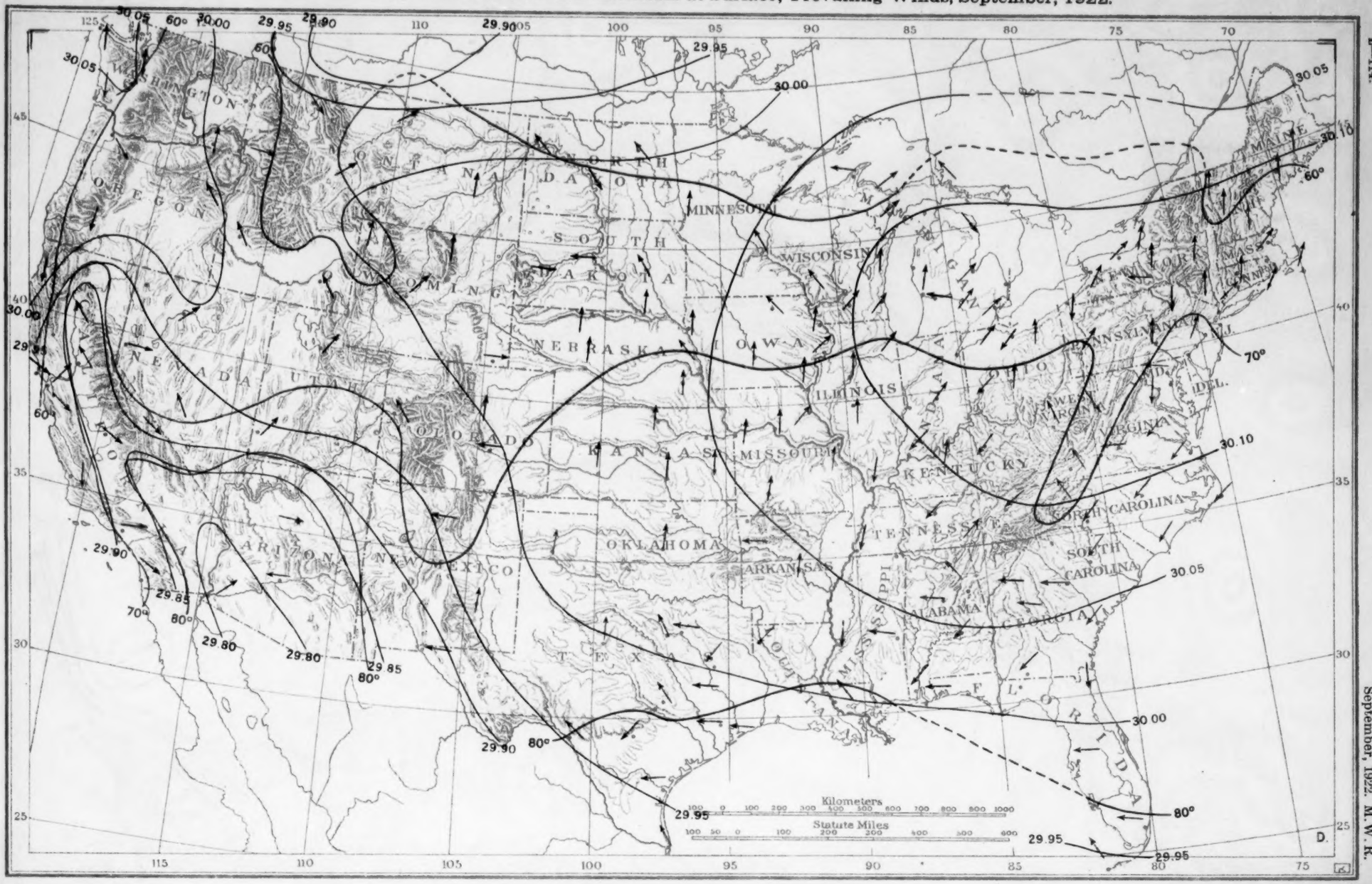


Chart VII. Weather Map of North Atlantic Ocean, September 18, 1922.

Chart VIII. Weather Map of North Atlantic Ocean, September 18, 1922.

(Plotted by F. A. Young.)

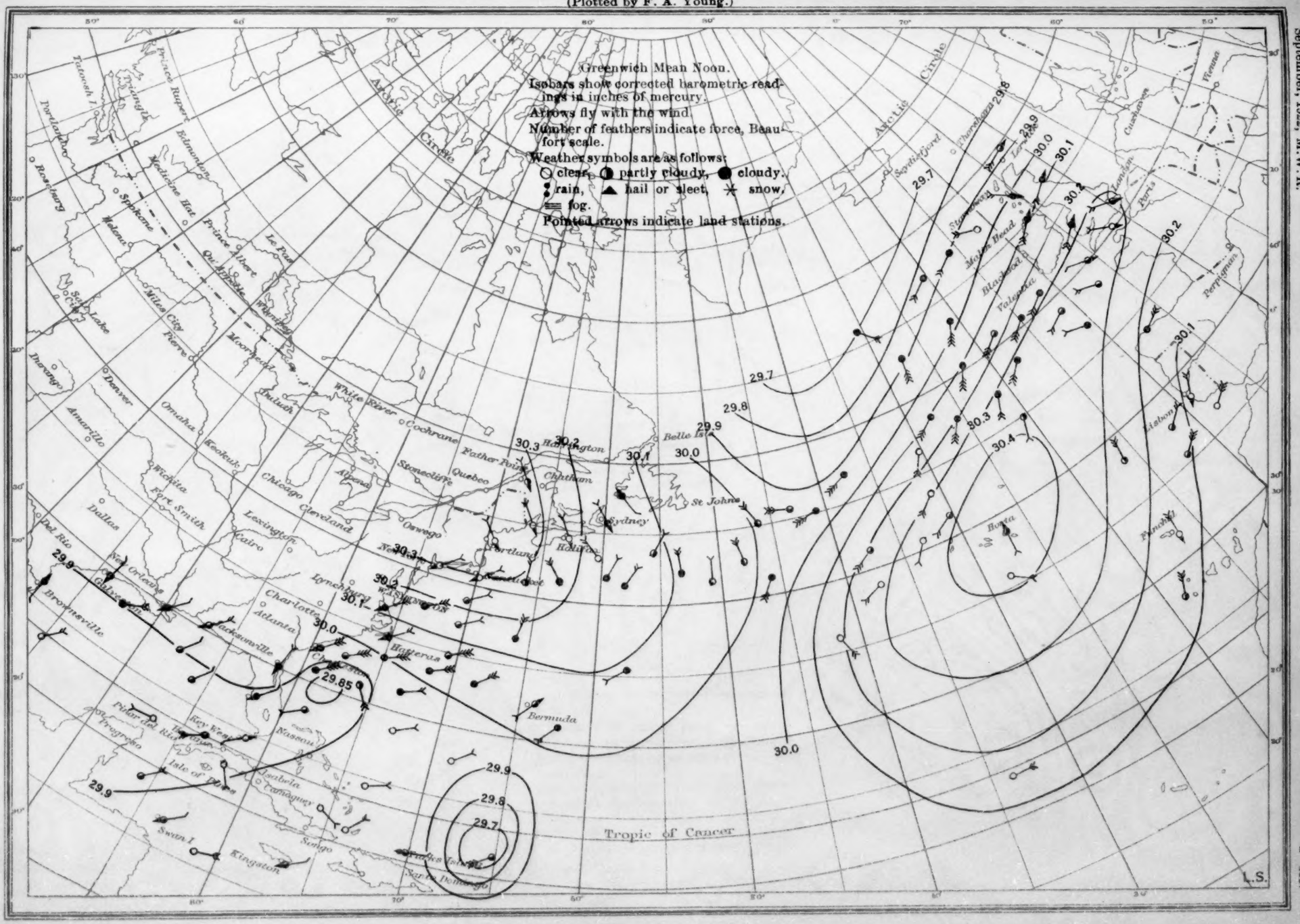


Chart IX. Weather Map of North Atlantic Ocean, September 19, 1922.

(Plotted by F. A. Young.)

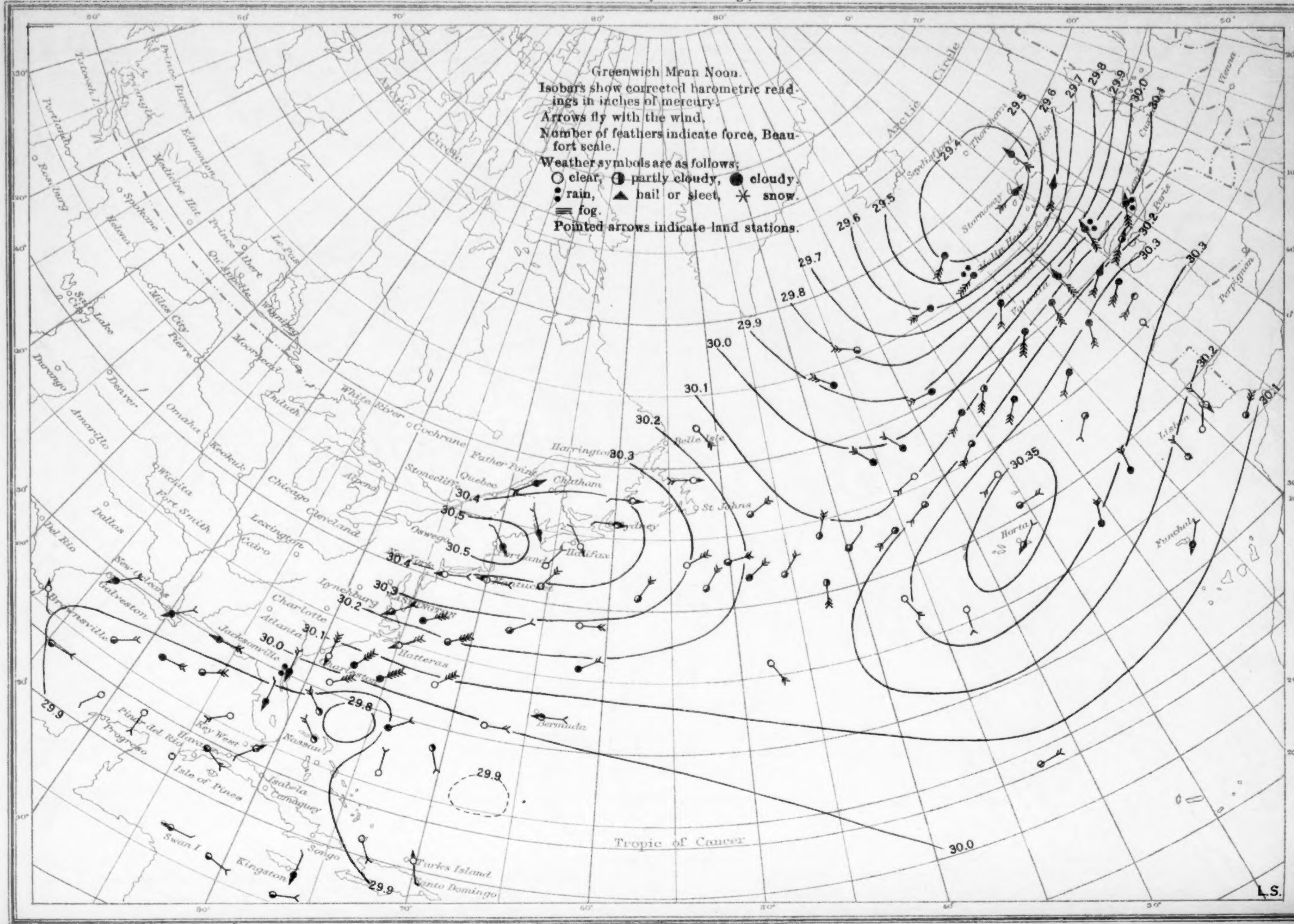


Chart X. Weather Map of North Atlantic Ocean, September 20, 1922.

Chart X. Weather Map of North Atlantic Ocean, September 20, 1922.

(Plotted by F. A. Young.)

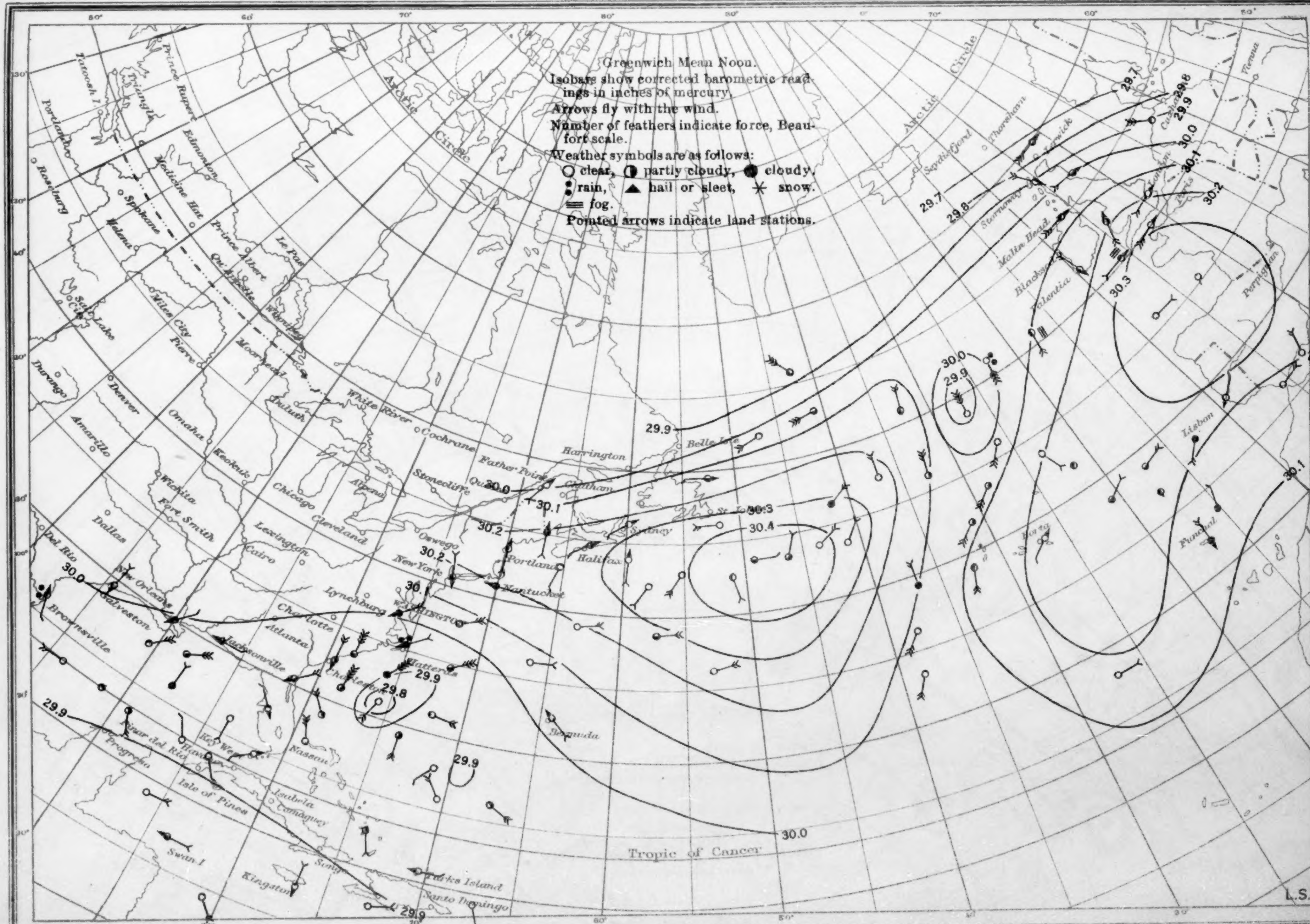


Chart XI. Weather Map of North Atlantic Ocean, September 21, 1922.

(Plotted by F. A. Young.)

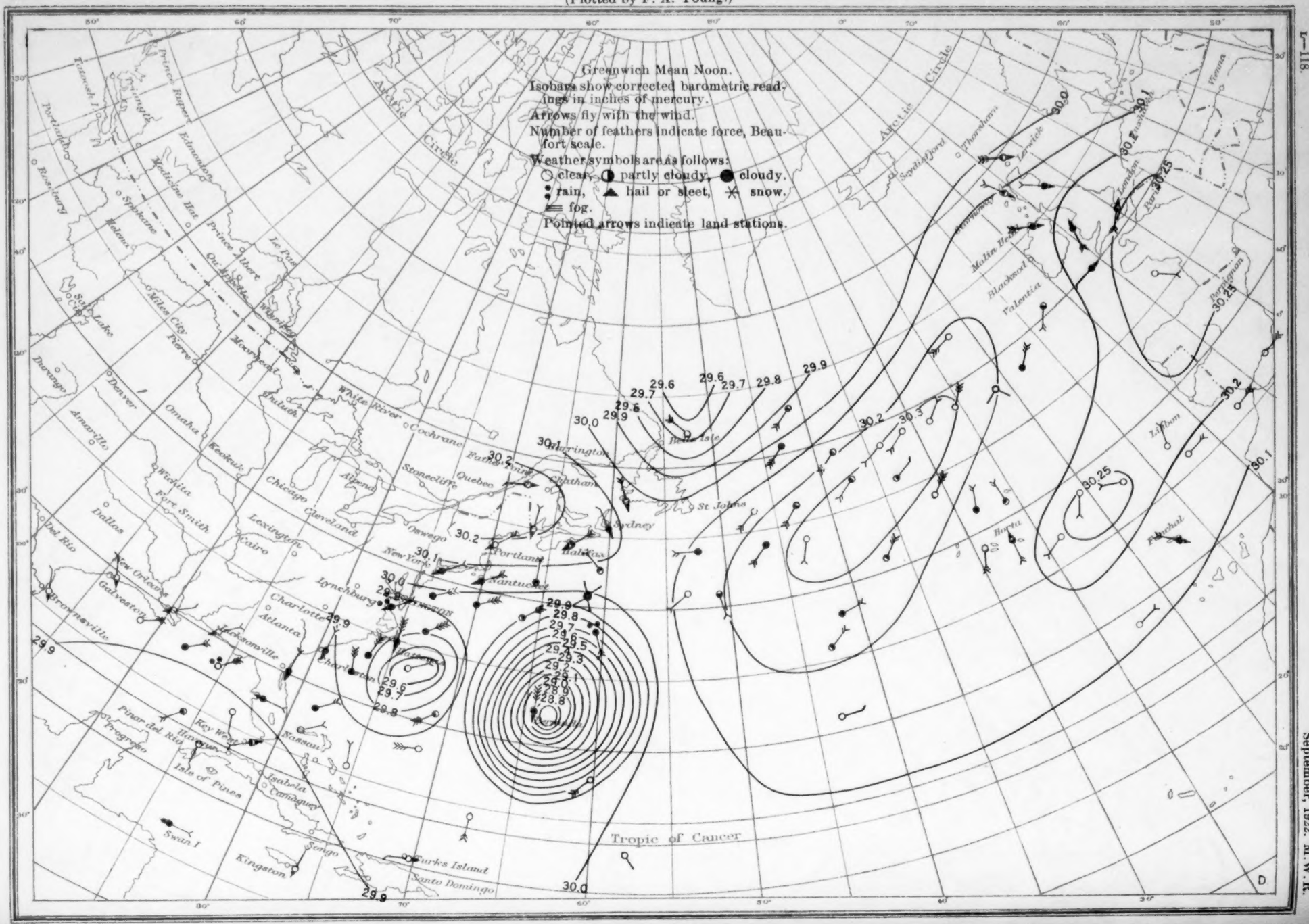

Greenwich Mean Noon.
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy.
rain, hail or sleet, snow.
fog.
Pointed arrows indicate land stations.
Arctic Circle
Tropic of Cancer
Prince Rupert
Edmonton
Medicine Hat
Winnipeg
Duluth
White River
Cochrane
Father Point
Quebec
Stonecliffe
Albany
Chicago
Cleveland
Oswego
Portland
Halifax
St. Johns
Sydney
Lexington
Cairo
Dallas
Denver
Omaha
Amarillo
Wichita
Fort Smith
Rockhill
Dodge City
Miles City
Havre
Swift Current
Prince Albert
Battleford
Moosejaw
Medicine Hat
Calgary
Edmonton
Prince Rupert
Vancouver
Portland
Seattle
Spokane
Walla Walla
Boise
Salt Lake City
Reno
Roseburg
Portland
Tatoosh I.
Port Arthur
Duluth
Minneapolis
Winnipeg
Lake Superior
Sault Ste. Marie
Toronto
Buffalo
Pittsburgh
Washington
Norfolk
Lynchburg
Charlotte
Atlanta
Jacksonville
Charleston
Savannah
Montgomery
Vicksburg
New Orleans
Galveston
Brownsville
Port Arthur
Lake Charles
Shreveport
Memphis
Nashville
Louisville
Cincinnati
Columbus
Detroit
Cleveland
Buffalo
Rochester
Albany
Boston
Nantucket
New York
Atlantic City
Baltimore
Washington
Norfolk
Hatteras
Wilmington
Charleston
Jacksonville
Key West
Havana
Nassau
Isle of Pines
Pinar del Rio
Progreso
Swan I.
Kingston
Santo Domingo
Turks Island
Isabela
Camaguey
Bermuda
Halifax
Sydney
St. Johns
Father Point
Quebec
Chatham
Parrsboro
Yarmouth
Lerwick
Thorshavn
Jan Mayen
Spitsbergen
Malin Head
Blacksod Bay
Valentia
Roches Point
Scilly
Lisbon
Funchal
Horta
Flores
Vienna
Berlin
Paris
Nantes
Brest
Ponta Delgada
Santa Maria
Flores
Horta
Funchal
Lisbon
Valentia
Scilly
Roches Point
Blacksod Bay
Malin Head
Jan Mayen
Spitsbergen
Thorshavn
Lerwick
Stornoway
Aberdeen
Kirkwall
Stavanger
Christiansund
Haparanda
Archangel

Chart XII. Weather Map of North Atlantic Ocean, September 22, 1922.

(Plotted by F. A. Young.)

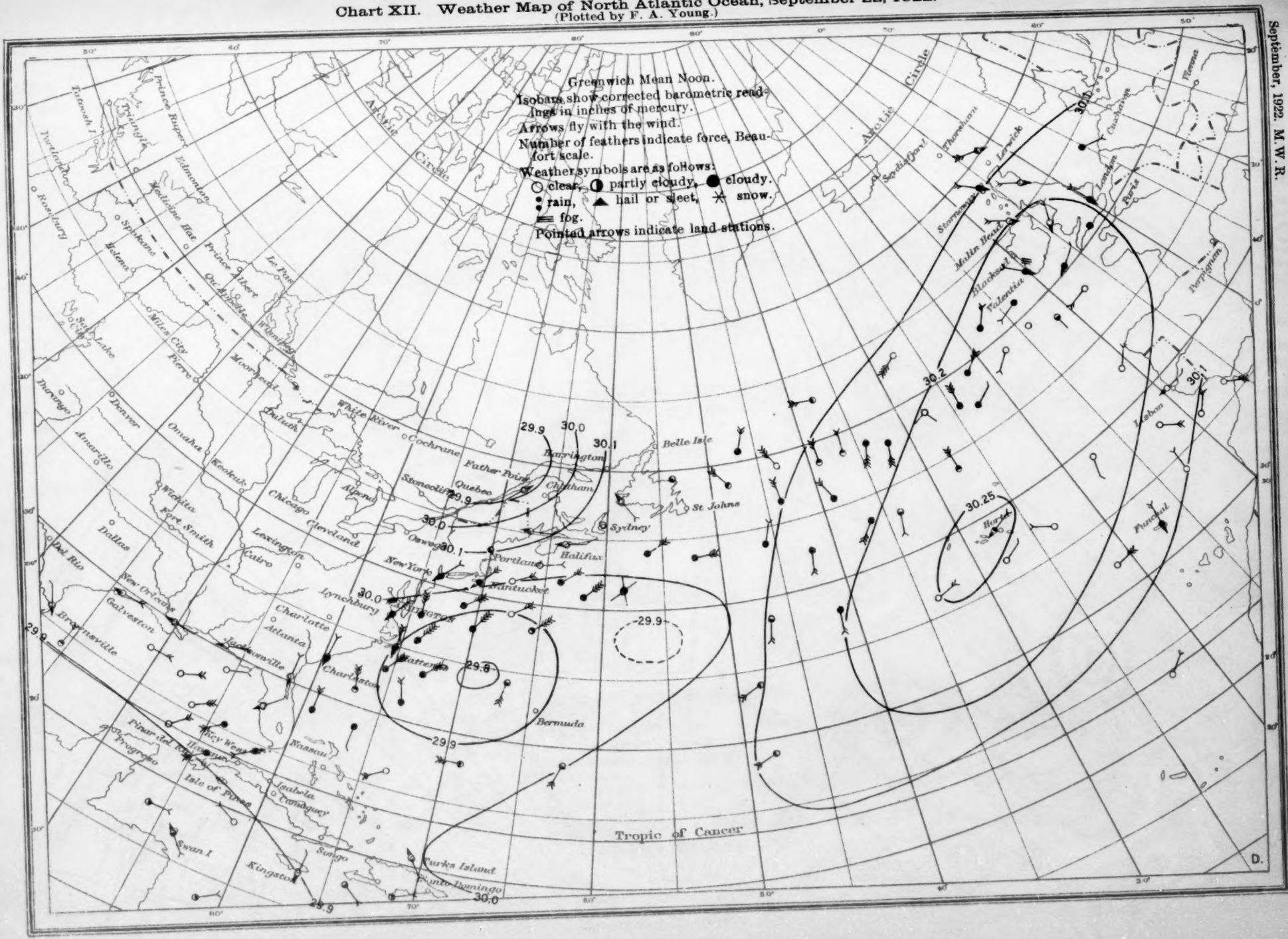


Chart XIII. Weather Map of North Atlantic Ocean, September 23, 1922.

(Plotted by F. A. Young.)

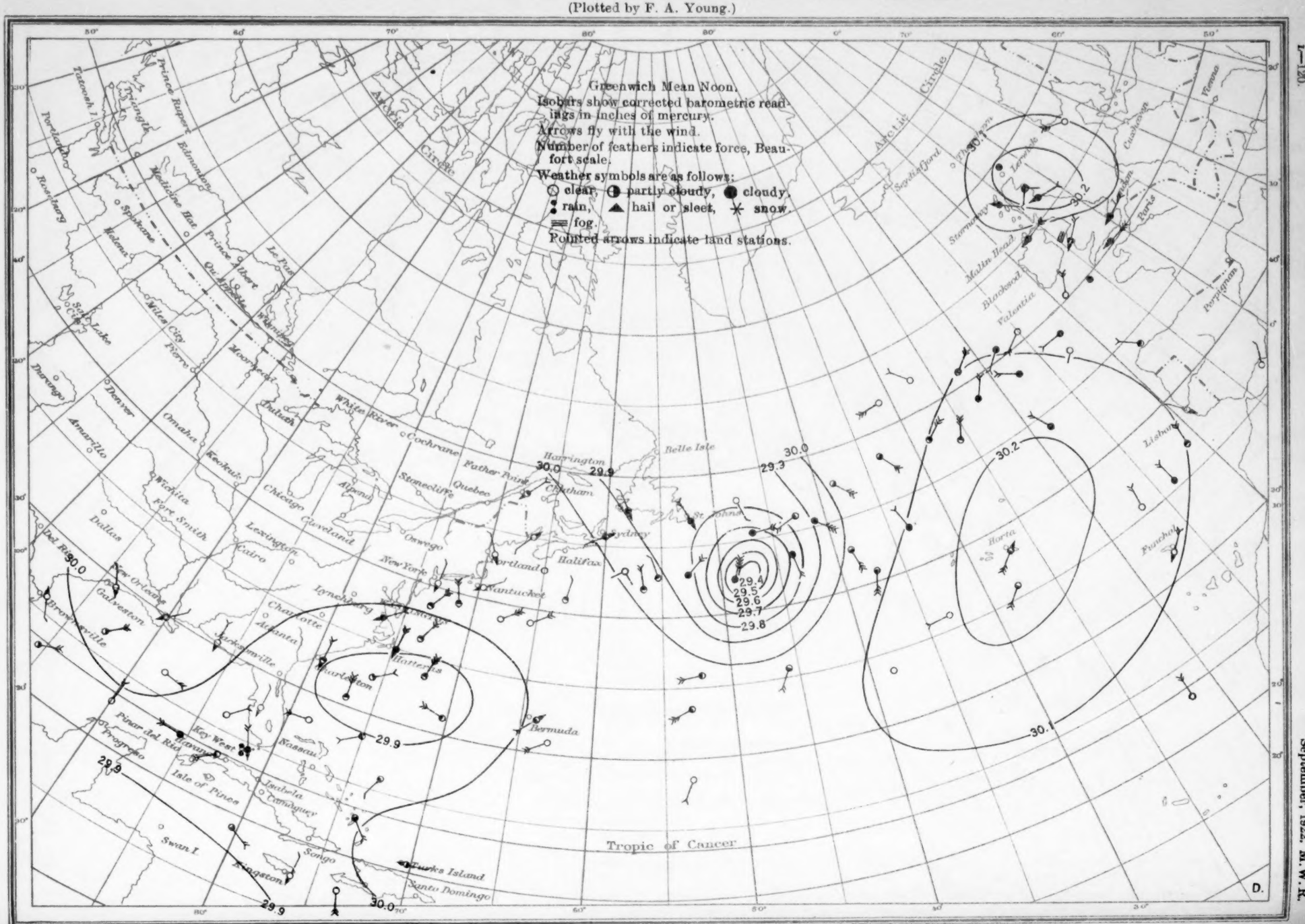


Chart XIV. Weather Map of North Atlantic Ocean, September 24, 1922.

Chart XIV. Weather Map of North Atlantic Ocean, September 24, 1922.

(Plotted by F. A. Young.)

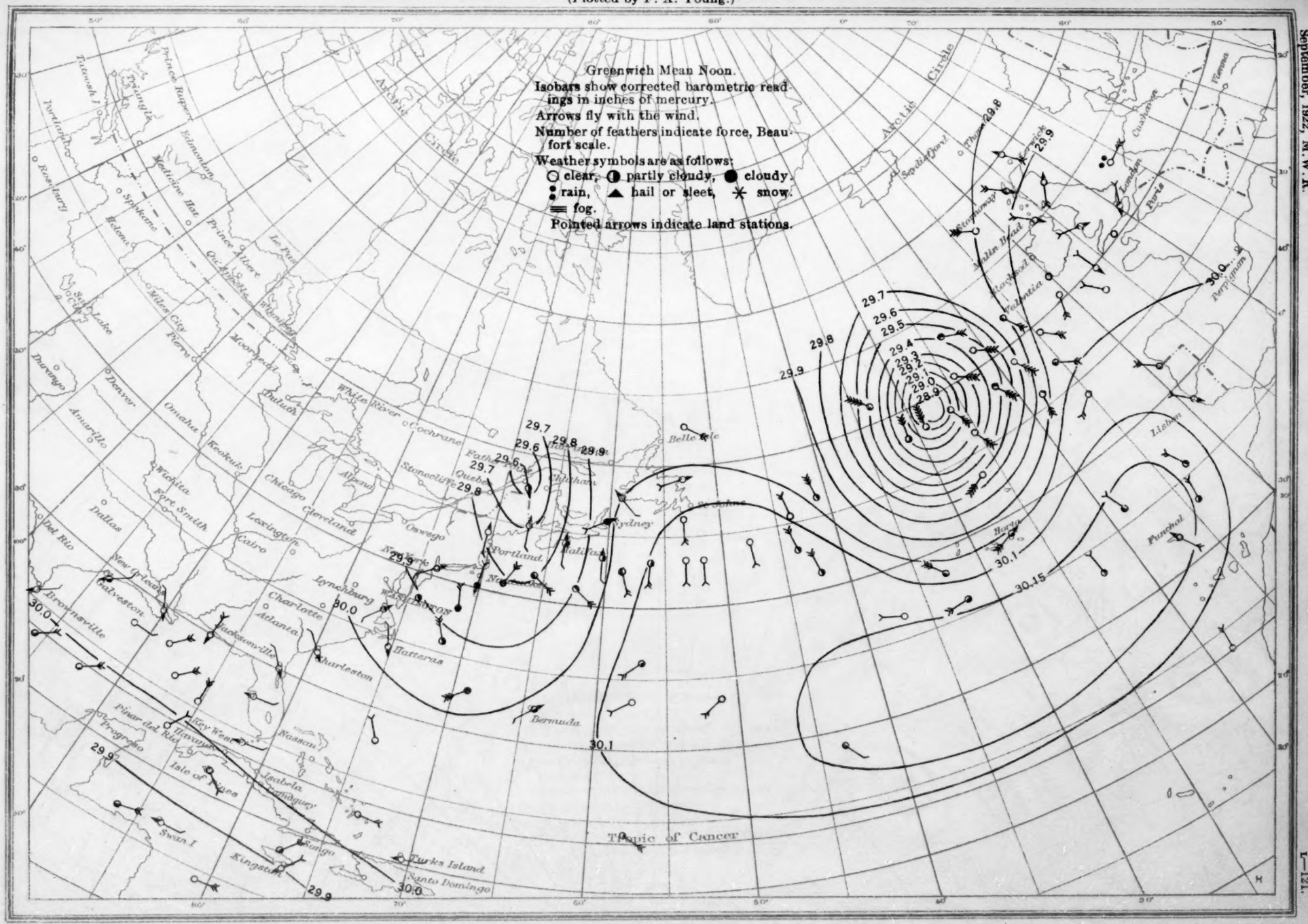


Chart XV. Weather Map of North Atlantic Ocean, September 25, 1922.
(Plotted by F. A. Young.)

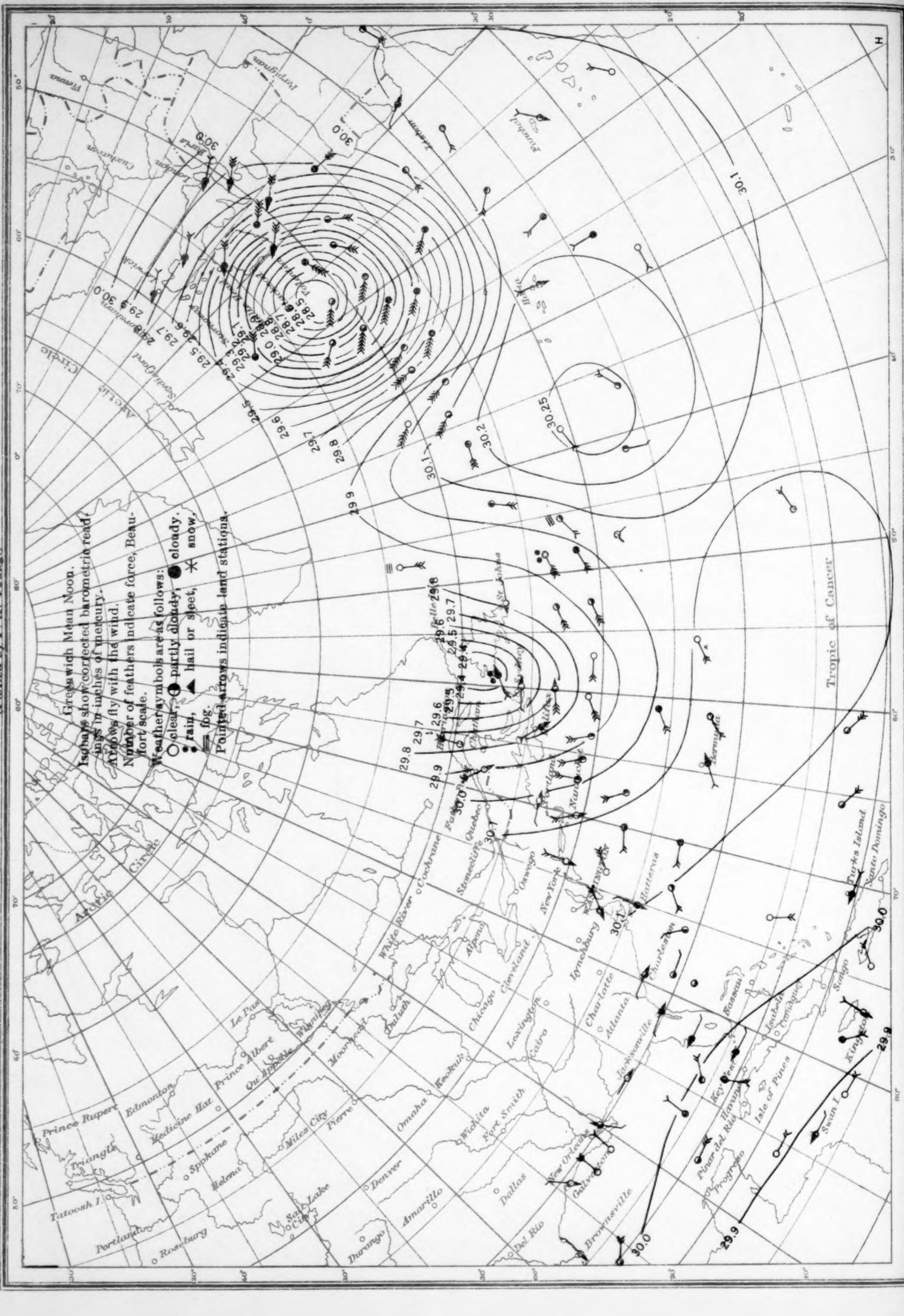
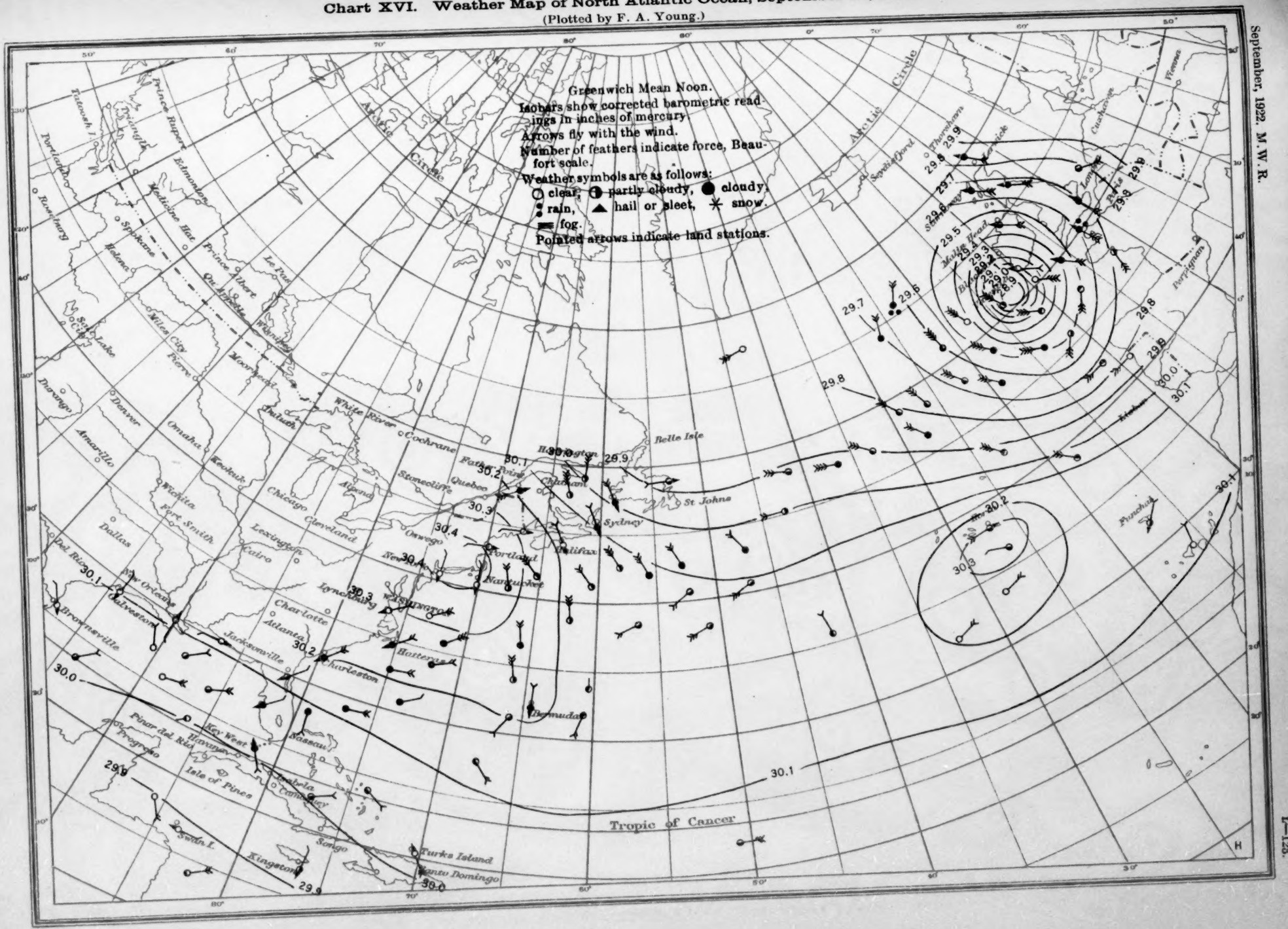


Chart XVI. Weather Map of North Atlantic Ocean, September 26, 1922.

(Plotted by F. A. Young.)



PUBLICATIONS OF U. S. WEATHER BUREAU.

For the free publications of the Weather Bureau apply to "Chief, U. S. Weather Bureau, Washington, D C."; for the others apply to "Superintendent of Documents, Government Printing Office, Washington, D. C."

Subscriptions for MONTHLY WEATHER REVIEW are at $1.50 a year. Single copies, 15c.

Subscriptions to the REVIEW do not include the Supplements; the latter are issued irregularly and at a fixed price. As a rule the Supplements will be abstracted in the REVIEW and a statement of the price will appear therein. Applications and remittances therefor should be forwarded to the Superintendent of Documents.

DETAILED CLIMATOLOGICAL DATA.

Detailed climatological data for the United States and its outlying territories are collected and published in the monthly reports, "Climatological Data," issued at the Section Centers by the respective officials in charge. They may be secured from the *Superintendent of Documents, Government Printing Office, Washington, D. C.*

A monthly volume, collecting under one cover all except Alaska, Hawaii, and Porto Rico, is issued, as above, at 35 cents per copy; or subscription per year, 12 monthly copies and annual summary, at $4.

Single sections, 5 cents each, or one year, 50 cents.

SEPTEMBER, 1922.

CONTENTS.

CONTRIBUTIONS, ABSTRACTS, AND BIBLIOGRAPHY.

	Pages.
The preparation and significance of free-air pressure maps for the central and eastern United States. C. L. Meisinger. (*Author's abstract*) (10 figs., 8 charts)	453–468
J. Bjerknes and H. Solberg on the life cycle of cyclones and the polar front theory of atmospheric circulation. A. J. Henry. (6 figs.)	468–474
Foot-layer densities of snow. H. F. Alps. (4 figs.)	474–475
A simple snow-density measurer. W. W. Korhonen. (Translation)	475–476
The climatograph: A new form of chart for climatic phenomena. E. N. Munns. (4 figs.)	477–481
The use of charts and graphs in the study of climate. V. B. Flanders. (2 figs.)	481–484
Dry months in the United States. A. J. Henry	484–485
Records of tornadoes in Tennessee, 1808–1921. R. Nunn. (3 figs.)	485–486
The heavy rainfall of September 2, 1922, at Washington, D. C. A. J. Henry	487
Sessions of the Meteorological Section of the International Union of Geodesy and Geophysics, Rome, Italy, May 4–9, 1922. H. H. Kimball	488
NOTES, ABSTRACTS, AND REVIEWS:	
Dr. Hellmann retires	489
New Norwegian weather maps	489
Climatological atlas of Norway	489
Boletim Meteorologico	489–490
The green ray	490
Is the atmosphere warmed by convection from the earth's surface?	490
Sunspot in high latitude	490
BIBLIOGRAPHY:	
Recent additions to the Weather Bureau library	490–492
Recent papers bearing on meteorology and seismology	492
SOLAR OBSERVATIONS:	
Solar and sky radiation measurements during September, 1922	492–493
Measurements of the solar constant of radiation at Calama, Chile	493

WEATHER OF THE MONTH.

†Weather of North America and adjacent oceans	494–498
†Notes on weather in other parts of the world	498
Details of the weather of the month in the United States—	Page.
General conditions	498
Cyclones and anticyclones	499
Free-air conditions	499–500
The weather elements	500–502
Storms and warnings. Weather and crops—	
Weather warnings	502–503
Rivers and floods	503–504
Effect of weather on crops and farming operations	504
Tables—	
Climatological tables	505–509
Seismological tables	509–514

† In marine separate.

CHARTS.

	Serial number.
I. Tracks of centers of anticyclonic areas	109
II. Tracks of centers of cyclonic areas	110
III. Departure (°F) of mean temperature from the normal	111
IV. Total precipitation, inches	112
V. Percentage of clear sky between sunrise and sunset	113
VI. Isobars at sea level and isotherms at surface; prevailing winds	114
VII. Total snowfall, inches (not charted)	
VIII–XI. Weather maps of North Atlantic Ocean, September 18–26, 1922	115–123
C. L. M. I–VIII. Free-air pressure charts	124–131

CORRIGENDA.

REVIEW, March, 1922:

Page 130, Table 3, for 1921, the actual rainfall departure published as "−0.2" *should be* "−2.9."

REVIEW, June, 1922:

Page 310, second column, fifth line, "coloring" *should read* "curvature."

REVIEW, July, 1922:

Page 366, article "Predicting minimum temperatures, etc.," second column, paragraph 2, the third sentence *should read as follows:* "The depression of the minimum temperature below the evening dewpoint is greater when the moisture content is high than in the case where there is less moisture."

Page 367, first column, paragraph headed "(Method C)," in the sixteenth line *omit* the words "or less than" *immediately preceding* "86 per cent."